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of Engineers®**



Project EM Task Force

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PHASE 2 REPORT

*Fernald Environmental Management Project
Critical Analysis of Operable Unit 4
Vitrification and Potential Alternatives*

*Prepared by:
US Army Corps of Engineers
for the US Department of Energy
Office of Environmental Management*

August 1, 1997

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Acknowledgment

The Project EM team wishes to express their sincere thanks to the staffs of DOE Fernald and Fluor Daniel Fernald for their outstanding professionalism and support during the execution of this study. Their input and constructive challenges to the Project EM team findings served to make this report a useful, defensible product.

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Executive Summary

In Project EM, the U.S. Army Corps of Engineers (USACE) provided technical assistance to the U.S. Department of Energy (DOE) Office of Environmental Management (EM) related to the baselines supporting the Ten-Year Plans (TYPs) for remediating contamination at DOE-EM sites around the country. In Phase 1, the USACE reviewed the cost estimates, work scopes and schedules comprising the baselines, made recommendations for improving these baseline components and identified specific areas that appeared suitable for further investigation. Phase 2 consisted of detailed analyses focused on quantifying potential cost reductions in specific TYP programs, projects and activities.

This Project EM team performed a Critical Analysis (CA) of Operable Unit (OU) 4 Vitrification and Potential Alternatives at the DOE site in Fernald, Ohio (see Appendix A for the definition of CA). The Record of Decision (ROD) for OU4 remediation consists of removing waste from three of four on-site concrete storage silos, stabilizing the waste using vitrification, and packaging and transporting the product to a disposal area. The waste material in Silos 1 and 2 consists of radium-bearing residues from pitchblende ore processes (K65). Silo 3 contains dry uranium oxide and other metal oxides. Silo 4 is empty and has never been used.

Among the documents it reviewed, the Project EM team took its key assumptions from four previous studies. In addition to the "Feasibility Study Report for Operable Unit 4" (FS) and the ROD, the DOE had commissioned a value engineering (VE) study, completed by the site in January 1996, and a Silo's Project Independent Review Team (IRT) study, completed in November 1996.

The purpose of the Project EM CA was as follows.

- 1) Review the vitrification path forward and assess the implementability/viability of vitrification as the selected stabilization method for the silo wastes within a reasonable time and cost.
- 2) Review the cost estimates provided by Fluor Daniel Fernald for the FS and the IRT study and assess their reasonableness.
- 3) Perform a VE study on the OU4 remediation concept.

The Project EM CA was performed on-site from March 10 - 21, 1997. The principal team effort was performing the VE study, and all of the cost benefits discussed in this report derived from the VE effort. The vitrification and cost estimate reviews were accomplished by the Project EM team vitrification experts and cost specialists. The findings and recommendations resulting from the CA are as follows:

- 1) Vitrification Review Results - The CA of the vitrification process indicates the ROD decision to vitrify the waste was correct based on disposal criteria and cost data available at the time.

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However, based on new information as noted below, the Project EM team advocates using solidification¹ in lieu of vitrification as the selected treatment technology.

- The costs quoted in the FS and ROD for vitrification were substantially underestimated due to lack of industry experience with the vitrification process at the time.
 - The ROD assumed that the silo waste would be processed in the same duration for both vitrification and solidification. The VE findings indicate that processing using solidification can occur in a much shorter duration than for vitrification. This time savings impacts the overall project cost and allows quicker site remediation. However, to keep transport to Nevada Test Site from controlling the waste processing rate, temporary onsite storage of the treated waste will be necessary.
 - The assumptions used to estimate treated waste volumes are based on treatability studies performed to date. Adjustment of such parameters results in substantial cost benefits if solidification is selected. Additional treatability tests should be performed to determine the optimum waste volumes.
 - The Vitrification Pilot Plant's six month operation demonstrated several technical difficulties associated with vitrification, especially melter design and operation. These data clearly show vitrification to be more difficult, time consuming and expensive than originally anticipated.
- 2) **Cost Estimate Review Results** – The documentation reviewed by the Project EM team was a pre-conceptual cost estimate and schedule with a sensitivity range of -30% to 50%. Evaluation of the cost estimate support documentation revealed numerous errors, such as duplicated costs, numbers transferred inaccurately, and unsubstantiated costs. Errors in this documentation also indicated a lack of quality control.
- 3) **VE Study Results** – The Project EM team identified potential cost benefits of up to \$372.9 million for implementing solidification for all silo waste relative to the \$604 million estimate for vitrification of Silos 1 and 2 if these suggestions are successfully implemented (ROD Alternative 3). (Since these benefits are based on current estimate documentation, they may include the cost estimate errors described previously.) This includes the following cost reducing recommendations:
- Solidify the waste from all three silos using a solidification process. The type of solidification process will depend on remediation contractor recommendations and treatability study results. This could result in \$46 million of cost benefits. Note that this proposal will require review and possible revision of the FS and the ROD. This could impact cost and schedule.

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¹ Solidification (solidify) refers to waste treatment processes (other than vitrification) whereby the hazardous constituents and water are chemically bound (stabilized) to form a solid mass that meets regulatory and waste disposal requirements.

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- Replace silo superstructures with a tower crane to support the retrieval operation. This could result in \$6.7 million of potential cost benefits.
- Increase the waste loading from 20% to 45% in the solidified mass. This could result in \$132.1 million of potential cost benefits.
- Utilize one turnkey contractor to design, construct and operate one batch plant to treat all the waste in Silos 1, 2 and 3. This single plant would replace the two separate batch plants (one for Silos 1 and 2 waste, one for Silo 3 waste) proposed in the ROD. Operation would commence based on two 8 hour shifts versus the one 8 hour shift originally planned. This could result in \$136.5 million of potential cost benefits.
- Use white metal boxes with internal shielding for the waste packaging, instead of SEG concrete boxes. This could result in \$51.6 million of potential cost benefits.
- Construct a single, simplified radon treatment system for all radon control. No cost benefits were calculated for this proposal because of the uncertainty surrounding the actual system required. The study team is confident that one simplified system will be more economical than the two elaborate systems and existing treatment system upgrade now identified in the OU4 concept. This recommendation is a good fit with the recommendation to use a single turnkey and one batch plant for all Silo waste remediation.

In addition, the Project EM team makes the following general recommendations.

- Prepare an independent baseline cost estimate for the OU4 remediation concept. Cost credibility will be improved by correcting duplicate costs, documenting unsupported costs, evaluating production rates more closely, using appropriate percentages for project management (PM) and construction management (CM) costs, applying contingency and consistently rounding off numbers.
- Proceed with the Silo 3 stabilization RFP as rapidly as practicable to: a) obtain experience in turnkey subcontracting; b) gain insight into responses, costs, schedules, implementation and management of turnkey subcontracts; c) obtain information and experience in solids removal from Silo 3 and transport to the process treatment system; and d) obtain experience in treating (cement solidification) of silo waste. In addition, some consideration should be given to methods of providing an opportunity for the "successful" subcontractor to have an option to treat the Silos 1 and 2 waste.

These recommendations by the Project EM team represent the results of an independent review of OU4 vitrification from a cost and technical perspective. The team recognizes that other regulatory and stakeholder concerns affect the decision-making on vitrification, but the team's analysis focused solely on the technical advantages and disadvantages of vitrification versus other alternatives.

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1. Introduction and Background

1.1 Project EM Background

Through Project EM, the U.S. Army Corps of Engineers (USACE) provided technical assistance to the U.S. Department of Energy (DOE) Office of Environmental Management (EM) related to the baselines supporting the Ten-Year Plans (TYPs) for remediating contamination at DOE-EM sites around the country. A baseline is a cost estimate for a specific scope of work performed at the site over a defined period of time.

During Phase 1 of this effort, the USACE reviewed the cost estimates, work scopes and schedules comprising the baselines and made recommendations for improving these baseline components. Phase 1 was essentially a reconnaissance-level assessment of the existing cost estimates, technical scopes, schedules and supporting data for the baselines at thirteen DOE-EM sites. During the Phase 1 assessments, USACE teams identified specific areas that appeared suitable for further investigation in the next phase.

Phase 2 consisted of detailed analyses focused on quantifying potential cost reductions in specific TYP programs, projects and activities. The benefits from cost avoidance or cost reduction could then be used to accelerate completion of other priority activities within the environmental management programs at those sites.

This report documents the analysis and results of one of these Phase 2 tasks. This report is to stand-alone and be used to understand and communicate about one area of potential cost benefits within the DOE-EM program.

1.2 Task Description

Phase 1 identified the need to perform a Critical Analysis (CA) of Operable Unit (OU) 4 Vitrification and Potential Alternatives at the DOE site in Fernald, Ohio. Specifically, the CA consisted of reviewing the selected vitrification alternative, analyzing cost estimate support documentation and performing a value engineering (VE) study. The task objective was to identify potential cost benefits that could be realized for various remediation alternatives being considered for the OU4 concept. Except for the cost reductions associated with correcting errors found in the current Fluor Daniel Fernald (FDF) estimates, all of the cost benefits discussed in this report derive from the Value Engineering study. A detailed discussion of the VE study is shown in Section 4.3.

The scope of the CA included the following tasks:

- 1) Evaluating overall processing of the K-65 wastes
- 2) Assess implementability/viability of the original technical and cost assumptions leading to the vitrification plant selection
- 3) Reviewing results from the Vitrification Pilot Plant (VitPP) to verify whether any unforeseen factors negatively or positively biased the results of the vitrification process

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- 4) Reviewing results from the VitPP as they pertain to the original assumptions of the cost/technical feasibility
- 5) Determining feasibility and reasonableness of vitrification as the preferred alternative based on the waste processing quantity assumptions
- 6) Analyzing the costs used to develop estimates for outyears, including management costs
- 7) Comparing vitrification to other alternatives that meet the regulatory objectives
- 8) Evaluating waste retrieval and transport systems from Silos 1 and 2
- 9) Reviewing cost estimates for vitrification of Silos 1 and 2 and solidification² of Silos 1, 2 and 3, and confirming the reasonableness of the estimates
- 10) Reviewing and analyzing the technical basis for selecting vitrification, which tracks back to the "Feasibility Study Report for Operable Unit 4" (FS), February 1994; and documenting the changes in assumptions and costs from the current cost estimate to the baseline and from the baseline in the FS information

All cost estimates used during the VE effort were pre-conceptual level estimates provided to the team by FDF. The team made no effort to either validate the estimates or prepare independent estimates.

2. Methodology and Approach

2.1 Team Composition

The Project EM team consisted of multidisciplinary members, including a VE facilitator, waste stabilization/vitrification experts, process/chemical engineers and cost engineers. Brief resumes for the team are provided in Appendix B. Members of the team were:

- Steve Fink, PE USACE, Walla Walla District – Team Lead
- Gail Bingham Consultant
- Scott Davis Dames & Moore
- Kurt Fisher DOE, Office of Environmental Management
- Gary Haddle, CCC Project Time & Cost, Inc.
- Tim Jamison, EIT Project Time & Cost, Inc.
- Robert Kupp Dames & Moore

² Solidification (solidify) refers to waste treatment processes (other than vitrification) whereby the hazardous constituents and water are chemically bound (stabilized) to form a solid mass that meets regulatory and waste disposal requirements.

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- Doug Maynor DOE, Ohio Field Office
- Laura Tate, PE USACE, Omaha District
- Joe Waits, PE, CVS Dames & Moore
- Mark Wichman, PE USACE, Omaha District
- Dave Yockman DOE, Fernald

2.2 Schedule

The schedule for completion of the CA was as follows:

March 10 – 21	Perform VE at the site
March 24 – 27	Prepare draft VE report
March 31 – April 4	Prepare draft report; continue cost estimate review
April 7 – 21	QC/finalize draft report
April 22	Issue draft report to DOE
April 30	Discuss draft report with site personnel
August 11	Issue final report

2.3 Methodology Used

2.3.1 Vitrification Review

The Project EM team evaluated the selection of vitrification as the remedial technology of choice for the OU4 concept. Specifically, the team focused on the following:

- Assessing conclusions regarding the VitPP to verify whether unforeseen factors negatively or positively biased the results and relating the pilot plant results to the original assumptions of the cost/technical feasibility
- Evaluating the assumptions for waste processing quantities and relating them to the feasibility and reasonableness of using vitrification as the preferred alternative to treat such quantities
- Reviewing and assessing the original technical and cost assumptions that led to the vitrification as the selected technology

2.3.2 Cost Estimating Review

In its cost estimating review, the Project EM team performed an evaluation of the OU4 Vitrification and Potential Alternatives supporting cost documentation. The documentation reviewed was titled "FEMP Budget Estimate Details" for fiscal year 1996 (FY96) and was a pre-conceptual cost estimate and schedule (with a sensitivity range of -30% to +50%) prepared by FDF. This documentation was used by FDF to resource load a schedule for cost comparisons to

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determine the path forward of the OU4 remediation project. The review included both general and detailed examinations of the information available. The general examination encompassed general problems and errors in the cost documentation, such as cost duplications and unsupported large cost allowances. The detailed review focused on line item comparisons to check the reasonableness of assumed productivities and other itemized cost components. The direct cost components for these detailed items were validated against existing industry standards from two sources: 1) USACE NAT95A "Unit Price Book" (UPB); and 2) "Means Estimating Manual." Note that standard adjustments were developed and applied to industry standards to account for crew productivity losses experienced on DOE field sites.

Cost tables and information included in the FS were also reviewed. To the extent possible, FS documentation was first checked for calculation errors and erroneous assumptions. Changes in costs were then tracked to current estimate support documentation and assumptions.

2.3.3 VE Study

The VE study workshop was held March 10-21, and a list of those who participated is included in Appendix C. The VE study team included members from USACE, Project Time & Cost, Inc., Dames & Moore and DOE. A certified value specialist facilitated the VE study. An oral presentation of the status of the study was made to DOE on March 21 by the Project EM team leader.

The VE study included brainstorming sessions by Project EM team members. Appendix D provides a list of ideas that resulted from the brainstorming sessions. After the brainstorming sessions, proposals were developed by the team which are based on alternative ways to perform project functions. These proposals are not intended to criticize the current concept. Rather, they should be considered as project enhancements.

These recommendations by the Project EM team represent the results of an independent review of OU4 vitrification from a technical perspective. The team recognizes that other regulatory and stakeholder concerns affect the decision-making on vitrification, but the team's analysis focused solely on the technical advantages and disadvantages of vitrification versus other alternatives.

2.3.3.1 The Job Plan

The study followed a generic, five-step process endorsed by the USACE and the Society of American Value Engineers, which is the professional organization of value engineers in the United States. The steps consist of the following:

- 1) Information gathering
- 2) Speculation
- 3) Analyses
- 4) Development
- 5) Presentation

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2.3.3.2 The Project

The project consists of: removing waste from three of the four on-site concrete storage silos; stabilizing the waste using either vitrification or solidification, and packaging and transporting the stabilized waste for disposal at the Nevada Test Site (NTS); demolishing and disposing of the silos and ancillary structures; and disposing of the berm and soil. The waste material in Silos 1 and 2 consists of radium-bearing residues from pitchblende ore processes. Silo 3 contains dry uranium oxide and other metal oxides. Silo 4 is empty and has never been used.³ A more detailed description of the project is contained in Section 3 of this report.

2.3.3.3 Key Assumptions

- All silo waste must be disposed off-site.
- The January 1996 VE study recommendation that Silo 3 waste be stabilized using a solidification process will be implemented.
- Waste can be stabilized to meet the regulatory requirements using a solidification process.⁴

2.3.3.4 Proposals

All VE proposals are included in Appendix E. The selected recommendations for change to the design are stated in Section 5 of this report. The Project EM team believes these changes will improve the overall project.

2.3.3.5 Design Suggestions

Some ideas of the study team that are not included in the list of recommendations due to time and other constraints may be worthy of further consideration. These ideas have been included as design suggestions for review by the site. Documentation of all design suggestions can be found in Appendix F.

3. Project Description and Background Information

OU4 is one of five OUs at the Fernald Environmental Management Project (FEMP) site. The materials stored within OU4 are classified as byproducts of uranium processing activities. However, those wastes are also similar to mixed low-level waste and exhibit a wide range of properties. Most notable is the higher radiation level associated with the K-65 residues in Silos 1 and 2 versus the much lower direct radiation associated with cold metal oxides in Silo 3. Still lower levels of contamination are associated with the soils and building materials within OU4. To account for these differences, and for the varied cleanup alternatives applying to each waste type, DOE Fernald divided OU4 into three sub-units. These sub-units are described as follows:

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³ "Operable Unit 4 Conceptual Design Plan for Residue Retrieval System for the Fernald Residues Vitrification Plant Silo Superstructure," U.S. DOE Fernald Area Office, Project No. 40200, March 1996, Rev. 0, page 1-1.

⁴ DOE-Fernald, Silos Project Independent Review Team Final Report, April 1997.

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- Sub-unit A Silos 1 and 2 contents (K-65 residues and bentonite clay) and the sludge in the decant sump tank
- Sub-unit B: Silos 3 contents (cold metal oxides)
- Sub-unit C Silos 1, 2, 3 and 4 structures; contaminated soils within the OU4 boundary, including surface and subsurface soils and the earthen berm around Silos 1 and 2; the decant sump tank; the radon treatment system; the concrete pipe trench and the miscellaneous concrete structures within OU4; any debris (that is, concrete, piping, and so forth) generated through implementing cleanup for Sub-units A and B; and any perched groundwater encountered during remedial activities.

The remedy for OU4 selected by the Record of Decision (ROD) is a combination of the alternatives that were developed for each sub-unit. Removal, vitrification and disposal at NTS was selected for sub-units A (Silos 1 and 2) and B (Silo 3). Remediation of sub-unit C (silo demolition and soil material disposal) allows material disposal in the underground disposal facility on-site. The major components of the selected remedy are described below:

- Removing the contents of Silos 1, 2 and 3 (K-65 residues and cold metal oxides) and the decant sump tank sludge
- Vitrifying to stabilize the residues and sludge removed from the silos and decant sump tank
- Shipping the vitrified contents of Silos 1, 2 and 3 and the decant sump tank to the NTS for disposal
- Demolishing Silos 1, 2, 3 and 4 and decontaminating, to the extent practicable, the concrete rubble, piping and other generated construction debris
- Removing the earthen berms, excavating contaminated soils within the boundary of OU4 to achieve remediation levels, and placing clean backfill to original grade following excavation
- Demolishing the vitrification treatment unit and associated facilities after use, and decontaminating or recycling of debris prior to disposition
- Interim onsite storage of the excavated contaminated soils and contaminated debris in a manner consistent with the approved Work Plan for Removal Action 17 (improved storage of soil and debris) pending final disposition in accordance with the ROD for OU 5 and OU3
- Continuing access control and maintaining and monitoring the stored wastes inventories
- Maintaining institutional controls of the OU4 area such as deed and land-use restrictions
- Potentially adding treatment of stored OU4 soil and debris using OU3 and OU5 waste treatment systems
- Pumping and treating (as required) any contaminated perched groundwater encountered during remedial activities

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- Disposing of OU4 contaminated debris and soils consistent with the RODs for OU3 and OU5, respectively

Silos 1 and 2 contain 8,005 cubic yards (cy) of K-65 residues generated from the processing of high-grade uranium ore. The silos are large, cylindrical, above-grade concrete vessels with post-tensioned steel reinforcing. Each of the domed silos is 80 feet in diameter and 36 feet high at the center of the dome.

The K-65 residues contain large activity concentrations of radionuclides, including radium and thorium. These radionuclides contribute to an elevated, direct-penetrating radiation field in the vicinity of the silos and to the chronic emission of significant quantities of the radioactive gas, radon, to the atmosphere. The K-65 residues are classified as by-product materials, consistent with Section 11(e)2 of the Atomic Energy Act (AEA).

Silo 3 contains 5,088 cy of residues, known as cold metal oxides, which were generated at the FEMP site during uranium extraction operations in the 1950s. Silos 3 and 4 are identical in design and construction to Silos 1 and 2. The residues within Silo 3 are similarly classified as by-product materials pursuant to Section 11(e)2 of the AEA. Silo 4 was never used for waste storage; however, rainwater that infiltrated the silo was removed in 1989 and again in 1991.

Three distinct alternatives are referenced in the following analysis and recommendations:

- Alternative 1: The ROD-selected remedy of vitrifying waste from Silos 1, 2 and 3
- Alternative 2: Vitrifying waste from Silos 1 and 2 and solidifying waste from Silo 3
- Alternative 3: Solidifying waste from Silos 1, 2 and 3

The site's VE, completed January 6, 1996, recommended that Silo 3 waste be stabilized using the solidification process. Prior to the Project EM CA, an IRT evaluated the path forward for treatment and disposal of the silos waste. The IRT determined that Silos 1 and 2 waste could be stabilized to meet the regulatory requirements using a solidification process. The CA effort proceeded under the assumption that Alternative 2 was the currently accepted OU4 remediation concept. Table 1 shows pre-conceptual cost estimates as provided to the IRT and used for the Project EM review for Alternatives 2 and 3.

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Table 1

Category Description	Alternative 2 (in millions)	Alternative 3 (in millions)
Vitrification Pilot Plant Cost	\$12	\$9
Silo 3 Stabilization Cost	\$25	\$25
Final Remediation Engineering Cost	\$51	\$20
Final Remediation Construction Cost	\$135	\$68
Final Remediation Operation Cost	\$75	\$29
Waste Pkg/Shipping/Disposal Cost	\$80	\$198
Decommissioning and Decontamination (D&D)/Soils Remediation Cost	\$40	\$36
Project Management (PM) Cost	\$54	\$45
Waste Retrieval Cost	\$16	\$12
Hotel Cost ¹	\$116	\$116
Total Analyzed Cost	\$604	\$588

¹ Hotel Costs are defined in the site documentation as administration, utilities, landlord services, safety and security for years past FY05. DOE assumed hotel costs would total \$25 million per year unescalated.

Based on the information in Table 1 and additional support information, cost charts were developed to aid the Project EM VE brainstorming process. These charts are found in Appendix G.

4. Analysis

4.1 Vitrification

4.1.1 Pilot Plant Results

The original Vitrification Pilot Plant (VitPP) basis included a cost estimate of \$14.1 million (capital), which increased to \$66 million (life cycle); and a completion date of March 1996, which (prior to melter failure explained below) advanced to October 1997.⁵ During construction, startup and operation of the pilot plant, numerous design problems were identified. Some of these problems have been corrected, but many have not. The most significant design problems involved the melter and its eventual failure. An investigation of the melter failure indicated several serious problems including a three chamber melter, melter construction materials, bottom penetrations, electrode construction materials and the gem maker. The VitPP also demonstrated the need to separate Silos 1 and 2 waste from Silo 3 waste for treatment.⁶

Valuable experience and information was gained from the VitPP that will aid in the design, construction and operation of a vitrification facility. Additional considerations in making a path forward decision include the existence of an approved ROD, the strong desire of the stakeholders

⁵ From handout for March 22, 1997, Fernald Citizen's Review Group meeting.

⁶ "Vitrification Pilot Plant Melter Incident: Data Analysis and Path Forward Team" Draft Final Report, January 31, 1997.

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to vitrify the wastes and the fact that the vitrified product will greatly exceed regulatory requirements and effectively contain radon.

However, there are uncertainties associated with vitrification, not the least of which is cost and schedule. In addition, the proposed melter would be several times larger than any existing, waste vitrification melter and would create a number of uncertainties related to melter design and operation. Consequently, the team believes that a new pilot plant and additional testing will be required prior to final treatment. The current baseline only includes costs for additional surrogate testing.

4.1.2 K65 Processing

The IRT recently evaluated the path forward for treatment and disposal of the silo wastes. The IRT confirmed the FS results which concluded that there are two viable options for treating and disposing the silo wastes: vitrification and solidification. The IRT determined that both waste forms would meet applicable regulatory and waste disposal requirements.

A separate technical evaluation of the OU4 waste treatment was performed by Dr. John Kolts, Principle Scientific Advisor (see Appendix H). In his memorandum to Jack R. Craig, Director of DOE FEMP, Dr. Kolts states:

"I found no technical justification for the conversion of the Silo 1, 2, and 3 waste to a vitrified glass product....Based upon my analysis of the Silo 1, 2, and 3 hazardous and radioactive characteristics(which are relatively benign) and the risks associated with the high temperature vitrification of these same wastes I do not support the current efforts to vitrify these wastes."

The Project EM team has not thoroughly investigated other possible methods of treating the silo wastes. However, based on the assumption Dr. Kolts' observation and the IRT findings (that is, both waste forms are viable), the team offers the following comments and observations:

- Fernald does not have experience cementing the silo wastes at a pilot (or larger) level. There is, however, a reasonably large body of industrial information in support of solidification.⁷
- Because both treatment methods are viable, other factors will determine the treatment decision: cost, schedule, packaging, transportation, stakeholder desires, ROD and so forth. These factors need to be thoroughly evaluated for both options. Evaluation needs to include sufficient background and detail that the items become useful discriminators. Based on the VE study findings shown in Section 4.3 of this report, cost and schedule favor solidification.
- The industrial support base available to implement each option is vital. Support includes subcontractor competition, the availability of treatment units and past experience in operating the treatment process.
- Innovative packaging to reduce total waste volume and packaging and transportation requirements should be evaluated.

⁷ Treatability Study Report Operable Unit 4

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- Stakeholder and regulator input and the possible need to change an approved ROD must be considered.
- The Project EM team believes there are several major improvements that could be addressed to improve cost and schedule. These improvements are applicable regardless of the treatment method selected and include the following:
 - ◆ Waste Loading – Perform sufficient testing to validate the waste loading that can be reasonably achieved with each treatment method.
 - ◆ Waste Packaging – Evaluate and implement more cost-effective waste packaging.
 - ◆ Subcontracting – Implement subcontracting methods that emphasize turnkey subcontracting, incentivized contracts and performance payments.

The Project EM team believes both vitrification and solidification are viable treatment options. The team also believes, however, that vitrification is an expensive approach for treatment of the silo waste. Solidification is a quicker, simpler and cheaper approach. As such, solidification is more likely to meet estimated costs and schedules. Solidification does, however, produce more treated waste volume⁸. Questions remain concerning metal leachability, long term durability and radon emanation.

4.1.3 Validity of Original Technical and Cost Assumptions

The ROD for OU4 silo wastes was signed in December 1994. The ROD identified vitrification of the wastes and off-site disposal at the NTS as the preferred option. The ROD recommendation was largely based on the in-depth information on remedial alternatives presented in the "Feasibility Report for OU4" (see Appendix I, Table I1); and the nine criteria identified by U.S. Environmental Protection Agency (EPA) in the National Contingency Plan (EPA 1990), which must be evaluated for each alternative selected for detailed analysis as part of the Feasibility Study (Appendix I, Table I2). A comparison of these evaluations is presented in the Table of Remedial Alternatives (Appendix I, Table I3).

The results of these studies and comparisons clearly showed that, for waste from Silos 1, 2 and 3, vitrification met all criteria. However, the results also showed that solidification also met all criteria except for Criterion 4 (reduction of toxicity, mobility, or volume through treatment), which solidification only partially met. Solidification did not meet the volume reduction criteria.

The schedule and cost information available in December 1994 showed that for the two treatment methods, the schedules were identical. Silos 1 and 2 required six years to complete, and Silo 3 required three years to complete. Costs, however, clearly favored vitrification with Silos 1 and 2 costing \$43.7 million to vitrify and \$73.1 million to solidify and Silo 3 costing \$28 million to vitrify and \$36 million to solidify. However, these estimates have been superseded by current estimates which show costs to vitrify higher than to solidify.

⁸ Volume increase will depend on waste loading and additives required to stabilize the waste. At 20% waste loading, the volume increase was calculated at 3.75 times. (1 yd waste = 3.75 yds stabilized product.)

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The data from the Treatability Study Report for Operable Unit 4 included four vitrification studies (two lab scale, one bench scale and one optimization):

1. PNL study of 1989 - total amount of material 400 grams melt of 70 grams.
2. PNL study of 1990 - 7 kilograms, 1 melt 968 grams, 1 melt 500 grams.
3. PNL study of 1992 - 14 kilograms total screen melts 100 grams verification melts of 1 kilogram each.
4. PNL Optimization study 1993-1994 - remainder of 14 kilogram screening melts 100 grams verification melts of 1 kilogram each..

Treatability studies were also performed for cement stabilization. However, these tests were primarily to determine a range of formulas for stabilization technology and were neither as extensive nor comprehensive as the vitrification test program. In any case, vitrification was selected as the treatment of choice, based on the following:

- Significantly reduces radon emittance
- Reduces leachability of metals and radiological constituents
- Reduces volume of waste for disposal
- Characteristics of silo material favorable to vitrification

Other factors that also led to the decision to vitrify included the following:

- At the time of the decision, there had been no design, construction or operation of a full scale production vitrification facility. A facility in Mol, Belgium had vitrified some high-level liquid waste, and the Fernald MAWS melter had vitrified some pit wastes and soils. Both efforts were successful. The MAWS, however, was a batch melter vitrifying a rather harmless waste.
- The decision to vitrify was made before either the West Valley Demonstration Project (WVDP) or the Defense Waste Processing Facility (DWPF) were operational. Both facilities were designed to treat high-level waste. WVDP was running cold tests with its first melter, and DWPF had not yet initiated melter cold operation.
- Because of the stage of WVDP and DWPF development, construction and operation, there was little information or few lessons learned from these projects to apply to the OU4 vitrification project.
- During this time period, DOE was actively and aggressively pushing new technologies. Therefore, vitrification (as a new technology) was seen as the answer to the waste treatment and disposal problem.
- Neither a detailed engineering cost estimate nor a schedule were prepared. The estimates used were rough order of magnitude. As now evident, the cost and schedule information was very optimistic.

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Based on these facts and given the environment, the decision to vitrify the silos' waste is not surprising. Given the same conditions and situation, others would probably have made the same decision.

4.2 Cost Estimate Analysis

4.2.1 Current Cost Analysis

As mentioned earlier, the Project EM team's cost analysis included both general and detailed analyses of the information reviewed and concentrated on Alternative 2 for the OU4 remediation. This alternative includes vitrification for the waste material in Silos 1 and 2 and solidification/stabilization for the waste material in Silo 3. Note that the scheduled completion date under the current estimate for this alternative is April 2011. The supporting cost documentation is organized into nine folders (categories) representing the current breakdown of costs for the OU4 remediation project. These costs include indirects and contingency but do not include escalation. Table 2 summarizes the current estimated cost for remediation of OU4 as presented to the IRT:

Table 2

Category Description	Alternative #2
Vitrification Pilot Plant Cost (Phase I Operations)	\$12,000,000
Silo 3 Stabilization Cost	25,000,000
Final Remediation Engineering Cost	51,000,000
Final Remediation Construction Cost	135,000,000
Final Remediation Operation Cost	75,000,000
Waste Pkg/Shipping/Disposal Cost	80,000,000
D&D/Soils Remediation Cost	40,000,000
PM Cost	54,000,000
Waste Retrieval Cost	16,000,000
Hotel Cost	116,000,000
Total Analyzed Cost	\$604,000,000

4.2.1.1 General Analysis

Initially, the cost information provided to the Project EM team was analyzed from a general perspective. This analysis revealed multiple problems indicating a lack of quality control regarding the maintenance of estimate support documentation. Documentation errors were identified in two areas:

- Cost duplications (double counting)
- Unsupported cost additions

In addition to the errors found in the supporting documentation, the organization of the information provided was less than adequate. On the surface, the support documentation

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appeared to be organized within the nine folders. However, the ability to track total costs into the cost-estimate summary spreadsheet by category did not always exist. Later, site estimating personnel pointed out that the summary spreadsheet information could be tracked to a resource loaded schedule (resource loaded with dollars from the estimate documentation). This schedule was not reviewed by the Project EM team (the schedule was not provided at the time of the CA). The inability to track costs from the estimate documentation provided to the summary spreadsheet, was partially due to this missing link. Note, some of the errors found to exist in the cost documentation were corrected when transferring to the resource loaded schedule.

4.2.1.1.1 Cost Duplications

Table 3 summarizes the type and amount of duplication found in the current cost estimate. For a full discussion of these findings, see Appendix J.1 of this report.

Table 3

Description	Cost (\$)
Net error duplicated cost found in Silo 3 Stabilization, Final Remediation Engineering and Final Remediation Construction cost categories	9,644,600
Additional net error ramifications	3,844,272
Contingency duplication for Waste Packaging/Shipping/Disposal cost category	10,501,815
Potential duplication for PM cost category	18,885,300
Potential PM duplication contingency (20%)	3,777,060
Total Cost Duplications Result	\$46,653,047

It is important to note that the total effect of identified and potential cost duplications equals over 12% of the current cost estimate for the OU4 remediation project.

4.2.1.1.2 Unsupported Cost Additions

The review of the cost estimates uncovered a significant, unsubstantiated allowance added to Waste Packaging/Shipping/Disposal costs. In addition, the level of Project Management cost included in the estimate exceeds established benchmarks and is determined in an apparently inappropriate manner. Correction of these two items results in potential benefits of \$58 million (see Appendix J.2).

There were several other significant allowances included in the current cost estimate that were not justified or supported in the documentation, as described in Appendix J.2. The nature of these items does not permit quantitative comparisons. However, the Project EM team recommends a detailed accounting of such allowances to more appropriately support the current estimate.

4.2.1.2 Detailed Analysis

A detailed review was also performed on the estimate support data provided to the team. This review included a random sampling of detailed line items. Direct cost components for these items

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were validated against existing industry standards from two sources: 1) USACE NAT95A UPB and 2) "Means Estimating Manual." Other comparisons were made based on stated assumptions on a case-by-case basis (see Appendix J.4).

4.2.1.3 Summary of Current Cost Analysis

The study team found supporting documentation to the current cost estimate to be unreliable. The documentation was incomplete, numerous errors were identified, labor productivity assumptions were inadequate and highly conservative, and the information did not track accurately within the documentation or to summary spreadsheets. Errors were found in the form of cost duplications, numbers transferred inaccurately, incorrect calculations and arbitrary cost rounding to \$1 million. Large unsupported cost additions were included without quantification or adequate supporting assumptions. Apparently, estimate documentation quality control is lacking.

Direct cost errors and inaccuracies affect indirect costs in several areas in the documentation such as training, payroll burdens and benefits, overhead/profit/bond, FDF field support and contingency. Additionally, detailed comparisons showed estimated labor productivities being consistently 50% lower than industry standards. This highly conservative approach to field work performance has obvious effects on the current OU4 remediation project schedule for completion. Costs such as PM and site "hotel" are currently duration driven. Therefore, schedule extension also implies cost increases in these categories.

The Project EM team recommends that an independent baseline cost estimate be prepared for the OU4 remediation project. Correcting errors in current documentation and independently evaluating unsupported costs and site support activities will result in significant reductions in the current estimate. An independent evaluation will also improve cost estimate credibility.

4.2.2 Comparison between the Current Estimate and the FS Estimate

In order to better understand the current cost estimate and to provide a sound framework for the VE study, the Project EM team compared the current (Alternative 2) estimate with the previous FS estimate. The results of this comparative analysis, including identification of changed or differing assumptions, can be found in Appendix K.

4.3 Project EM Value Engineering Study

4.3.1 Introduction

This section discusses the results of the VE study of OU4 Vitrification and Potential Alternatives. The study team is listed in Section 2.1 of this report. Team resumes and the VE Workshop participation matrix are included in Appendices B and C, respectively. The methodology is discussed in Section 2.3.3.

All of the VE proposals developed by the VE team are included in Appendix E. The proposals discussed in this section will be referred to by their identifiers.

4.3.2 Boundary Conditions

The following boundary conditions were accepted by the VE team.

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Boundary Condition 1 – All silo waste must be removed from OU4.

The DOE and FDF informed the team that on-site disposal or in-situ stabilization were not acceptable alternatives and should not be considered in the VE study. After lengthy discussion among the VE team members, the team accepted this as a boundary condition.

Boundary Condition 2 – Silo 3 waste will be stabilized using a solidification process (not vitrification).

The FS considered a number of options for treating the K-65 residues in Silos 1 and 2 and the cold metal oxides contained in Silo 3. Three alternatives that were presented in the ROD were:

- Alternative 1 – Vitrification of Silos 1, 2 and 3
- Alternative 2 – Vitrification of the K 65 residues in Silos 1 and 2, and solidification of the cold metal oxides in Silo 3
- Alternative 3 – Solidification for Silos 1,2 and 3

Alternative 1 was the ROD-selected remedial action. A VE study⁹ by DOE evaluated the Alternative 1 plan. That VE study recommended Alternative 2 (vitrify the K65 residues in Silos 1 and 2, and solidify the Silo 3 cold metal oxides). The results of that VE study were provided to the Project EM team as the starting point for the Project EM VE study.

Boundary Condition 3 - Solidification is viable for stabilization of the Silos 1 and 2 waste.

An IRT recently reviewed the treatment and disposal requirements for the silo waste and confirmed the Feasibility Study determination that both vitrification and solidification are viable treatment methods.¹⁰ For the purposes of this CA, the study team accepted the IRT findings.

4.3.3 Ideas and Recommendations

Part of the value engineering methodology is to generate as many ideas as practical, and then evaluate the ideas and select certain ones for further development. If the ideas thus selected turn out as expected, they are put forth as formal proposals. Only those ideas that are proven to the team's satisfaction are listed as recommendations.

A brainstorming session was performed that generated 126 ideas, of which twenty-one were developed as VE proposals. The creative idea list is included in Appendix D. The VE proposals are presented in Appendix E. Some ideas that did not make the selection for development as VE proposals due to time and other constraints were still considered worthy of further consideration. These ideas are shown in Appendix F.

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⁹ U.S. Department of Energy, Value Engineering Final Report, Project: Remedial Actions At Operable Unit 4, Fernald/, Record Of Decision Plan, January 26, 1996.

¹⁰ DOE-Fernald, Silos Project Independent Review Team Final Report, April 1997.

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4.3.4 Cost Basis

For comparison purposes, the pre-conceptual level cost estimates provided to the VE study team were assumed accurate. No attempt was made to correct the errors discussed in Section 4.2 of this report.

At the time of this VE study, Alternative 2 had an estimated cost of \$604,000,000, and Alternative 3 had an estimated cost of \$558,000,000. These estimates included VitPP cost, Silo 3 stabilization cost, final remediation engineering cost, final remediation construction cost, final remediation operation cost, waste packaging/shipping/disposal cost, D&D/soils remediation cost and PM cost and waste retrieval cost. VE cost models were generated from the Alternative 2 and 3 cost summaries, and these were used to identify the high-costs areas. The VE cost models are shown in Appendix G.

4.3.5 Discussion

The Project EM team performed the VE study knowing that both vitrification and solidification were viable treatment alternatives. Accordingly, the VE proposals that were developed address both treatment alternatives. The team strongly endorses silo waste treatment by solidification, based on the technical review of the vitrification path forward and the cost and schedule benefits identified during the VE process. Therefore, the following discussion below focuses on the solidification path forward. The reader should note that even if solidification is not implemented, cost benefits can be obtained from the VE proposals that address the vitrification path. As previously mentioned, all of the proposals are shown in Appendix E. Table 4, at the end of section 4.3.5, shows the best proposals developed for reducing the cost of the solidification path forward.

The silo waste remediation was divided into five functions: retrieval, treatment, packaging, transport/disposal and procurement. These are discussed in the following paragraphs.

4.3.5.1 Retrieval

The Project EM team accepted the existing concept for retrieval of Silo 3 waste. Instead, the team focus centered on the retrieval plan for the K65 waste in Silos 1 and 2 as defined in the OU4 Conceptual Design Plan¹¹. This item generated significant team debate. The K65 material has been characterized as silty clay, with a bentonite cap. The bentonite cap was added to help reduce radon emissions from the top of the silos. The present plan calls for constructing a superstructure over each silo (trussed bridge). Waste retrieval operations will be conducted from the superstructure, using slurry pumping as the retrieval method. Generally, the team concurred that waste retrieval using the slurry method is achievable, and two proposals focused on economizing that retrieval concept. Proposal A2.2, Use Tower Crane Instead of Two Superstructures for Waste Retrieval, was selected as the recommended plan.

However, a third proposal that merits strong consideration suggests implementing a retrieval method that minimizes the use of water during waste retrieval. The rationale behind this proposal

¹¹ U.S. Department of Energy, Operations Unit 4 Conceptual Design Plan For Residuals Vitrification Plant Silo Superstructure, Project No. 40200, dated March 1996.

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is that the cost for removing the excess water from the waste is significant, depending on the stabilization method selected. For solidification, additives must be placed in the thickened slurry to absorb excess water resulting in a volume increase that has a significant cost impact. The team did not support the minimum water retrieval idea for two reasons: 1) the ability to remove the K65 waste (characterized as silty clay) using dry retrieval methods such as augering is questionable; and 2) the reportedly poor structural integrity of the silos (as discussed in the ROD and other engineering documents) led the team to doubt that cutting into the silo walls would be allowed. An assessment evaluating the risk of cutting a hole through the silo dome relative to side entrance should be undertaken, prior to implementing this suggestion.

4.3.5.2 Treatment

Treatment evaluated three functions: treatment method, volume reduction and processing.

The Project EM team is unanimous in recommending solidification of the K65 wastes in Silos 1 and 2. The IRT found that solidification is a viable stabilization method, and other information provided to the team supported that finding. The team concluded that solidification could be accomplished faster and at less cost than vitrification. The team recognized that temporary storage of the treated waste will be necessary in order to keep waste transport from controlling processing throughput. Estimates provided to the study team showed that Alternative 3 would be \$46 million less expensive than Alternative 2.

If vitrification is pursued for Silos 1 and 2 waste using the proposed 6-ton-per-day melter, the study team strongly recommends additional pilot testing prior to proceeding with a production melter. This recommendation will result in a project completion slippage of from one to three years, and result in a cost increase of from \$8 to \$24 million to the extended site management and "hotel" costs.

In Proposal C5.1, Solidification, it was recognized that solidification caused a significant volume increase and associated high cost for packaging and disposal. Cementation studies to date by FDF have only demonstrated the ability to achieve a 20% waste loading for Silos 1 and 2 waste. However, those studies considered compressive strength as one of the qualifying criteria. Compressive strength is not one of the acceptance criteria for NTS. Based on information provided to the team, the team is confident that the Silos 1 and 2 wastes can be stabilized to meet the disposal criteria at a waste loading of at least 45% (the ROD assumed 20% waste loading). There is some evidence that the waste loading could be even higher (see Proposal C1.1, Treatment Consideration of Silos 1, 2 and 3). The team recommends additional treatability studies to maximize the waste loading. The cost for packaging/shipment/disposal of the Silos 1 and 2 waste at 20% loading was estimated at \$237,788,000. The cost of packaging, shipping and disposal decreases as the waste loading increases.

Proposal C5.4, Stabilization/Solidification, evaluates the benefit of performing the silo stabilization using one turnkey designed, constructed and operated batch plant instead of two. This proposal assumes sixteen hours operation per day. The batch plant should be designed to handle the worst-case waste stream. In so doing, significant benefits can be realized.

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4.3.5.3 Packaging

Another high cost item is the waste packaging required for shipping and disposal. Proposal D1.1, Waste Packaging/Shielding, evaluates an innovative method of using a much less expensive enclosure with the addition of foam as a shielding measure. If implemented, the cost benefits are significant.

4.3.5.4 Procurement

There appears to be significant cost benefits by procuring a single contractor to perform all silo waste remediation. This is discussed in Proposal D1.1 and is a good fit with Proposal C5.4, One Batch Plant.

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Table 4

Summary Of Recommended Proposals						
Description		Present Worth Amount				
I.D. #	Recommendation	Original Design	Recommendation	Resulting Cost Benefits	Adjusted Benefits of Recommendation	Notes
Vitrification Review Recommendation						
-	Solidify K65 Material	\$604,000,000	\$558,000,000	\$46,000,000	\$46,000,000	Added Hotel Cost (\$116,000)
VE Study Recommendations						
A2.2	Use tower crane to support retrieval	\$8,086,000	\$1,948,000	\$6,707,000	\$6,707,000	
C5.1	Increase waste loading from 20% to 45%	\$237,788,000	\$105,683,000	\$132,105,000	\$132,105,000	
C5.4	Construct one batch plant for all waste stabilization	\$133,900,000	\$60,227,000	\$73,673,000	\$136,506,000	Adjusted for schedule economy (hotel savings) ¹
D1.1	Package waste in white metal boxes with shielding	\$197,540,000	\$81,542,000	\$115,998,000	\$51,550,000	Adjusted for C5.1 ²
Total Potential Savings					\$372,868,000	

1 Adjusted for schedule economy. $(\$116,000,000/4\text{years}/12\text{months} \times 26\text{ months} = \$62,833,000)$

2 Adjusted for C5.1 waste loading. $(\$115,998,000 \times 20\%/45\% = \$51,550,000)$

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5. Recommendations

The Project EM team recommends that the following key initiatives be undertaken. Refer to Appendix E for further discussions of the referenced VE proposals. Other design improvements and procurement ideas are presented in Appendix F for additional consideration.

- 1) Implement Alternative 3 – Solidify the waste from all three silos using an appropriate solidification process. This could result in potential cost benefits of \$46 million over vitrification based on the comparative costs provided to the Project EM team. This recommendation will require additional administrative effort because the ROD will have to be revisited.
- 2) Implement VE Recommendation A2.2: replace silo superstructures with a tower crane. This could result in potential cost benefits of \$6.1 million.

The following recommendations apply only if Alternative 3 (solidify all silo waste) is implemented:

- 3) Implement VE Recommendation A1.2 – Construct a single simplified radon treatment system for all radon control. No cost benefits were calculated for this proposal. The study team is confident that one simplified system will be more economical than the two elaborate systems and an upgrade of the existing radon treatment now identified in the OU4 concept (vitrification of Silos 1 and 2 waste and solidification of Silo 3 waste).
- 4) Implement VE Recommendation C5.1 – Increase waste loading. This could result in potential cost benefits of \$132.1 million.
- 5) Implement VE Recommendation C5.4, E1.1, E1.2 and E2.1 – Utilize one turnkey contract to construct and operate a single batch plant to treat all three silos waste. This could result in potential cost benefits of \$136.5 million (assuming two eight hour shifts versus one eight hour shift as originally planned).
- 6) Implement VE Recommendation D1.1 – Use WMB with internal shielding. This could result in potential cost benefits of \$51.6 million.

The accumulative benefits for solidifying all silo waste and implementing the related VE proposals listed above total \$372.9 million. Implementing the proposal results in a waste treatment project cost of \$231.1 million, compared to the original estimate of \$604 million. The individual and collective benefits of those proposals are shown at the end of section 4.3 in Table 4.

Other recommendations of the team include the following:

- 1) If vitrification is pursued for Silos 1 and 2 using the proposed 6-ton-per-day melter, the team strongly recommends that additional pilot testing be performed prior to proceeding with a production melter. This recommendation could result in a project completion slippage of one-to-three years and a cost increase of \$8 million to \$24 million due to the extended site management and allocation costs.

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- 2) A structural risk analysis should be performed on Silos 1 and 2. The purpose of this analysis would be to evaluate the relative risk associated with cutting a hole in the silo dome (present concept) versus entering the silo through the side. If side entrance has less risk, this allows less expensive retrieval methods.
- 3) Dry retrieval methods should be revisited to validate its feasibility for removal of the K65 wastes from Silos 1 and 2. Benefits on the order of \$20 million could be realized if a method for dry retrieval can be identified. The benefits of this recommendation are discussed in Appendix E, Proposal A1.1, Minimize Water Use. The Project EM team did not support the proposal as presented because of the proposed retrieval methods described and the apparent questionable silo structural integrity. However, eliminating or greatly reducing the water introduced during waste retrieval is a good idea that merits consideration.
- 4) Solidification treatability studies should be performed on the wastes in Silos 1, 2 and 3 to determine the waste loading that can be achieved and still meet waste transport and disposal criteria. This report assumed a waste loading of 45% based on treatability studies conducted on similar wastes and on expert opinion. The study team is confident that 45% waste loading is achievable, but there is evidence that much higher waste loading may be possible (see Appendix E, Proposal C1.1, Maximize Waste Loading).
- 5) Prepare an independent baseline cost estimate and schedule for the OU4 remediation concept. Cost credibility will be improved by correcting duplicate costs, documenting unsupported costs, evaluating production rates more closely, using appropriate percentages for project management (PM) and construction management (CM) costs, applying contingency and consistently rounding off numbers. Basing the cost on a resource loaded schedule would also increase credibility.
- 6) If Alternative 3 (solidify all silo waste) becomes the selected plan for OU4 remediation, consider a single RFP for remediating all three silos. A discussion of this recommendation is provided in Appendix E, Proposal E2.1, Improve Contracting.
- 7) Encourage communication between the OUs. The team's impression was that the various OUs at Fernald maintained a degree of autonomy, and communication among them was minimal. Cost benefits may be realized by sharing appropriate infrastructure, lessons learned and other resources. This can only occur if the OUs are communicating among one another.

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Appendices

Text for the following appendix sections exist in hard copy only, or as separate electronic files, and are not part of the main electronic file for this report.

- Appendix E, pages E-4 through E-129, exist as hard copy and also as a separate Word Perfect 6.1 file named "AppxE-F.wpd."
- Appendix H exists as hard copy only.

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Appendix A

Definition of Critical Analysis

After the preliminary activity based cost estimate is prepared a CA may be performed that challenges the assumption of the "base cost" estimate and documents potential cost benefits associated with modifying or deleting DOE/site/contractor requirements. The CA also challenges these requirements, identifies impacts and action by comparing the estimate to industry standards and includes expert opinion of the program. In addition to cost estimators, workscope experts should be used to challenge the work tasks for necessity and completeness. The CA will result in identification of "could cost" opportunities.

Specific information is required to document the results that come from the CAs. The following aspects are considered the minimum requirements for a CA:

- Determine need for activity and provide basis for findings.
- Determine impacts to project if activity is not completed.
- Determine if the schedule duration for workscope can be decreased.
- Perform comparisons to other projects and industry standards and provide findings with material references, used to support recommendations or conclusions.
- State scope of activity in a clear and concise manner.
- State impacts to project for recommendations.
- List each recommendation with analysis - what did you look at to make recommendation.
- List an action statement for each recommendation - what must be done to initiate the recommendation (for example, changes/reduction in regulations and/or resources)
- Provide reference to materials, publication, and/or books used as basis of recommendation.
- Provide prioritization of recommendations for all activities.
- Develop recommendations on current requirements/waivers.
- All supporting documentation is on file and available.
- Provide validation of unit costs from database.

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Appendix B

Resumes of the Project EM Team

Steven J. Fink, P.E. - Team Lead

A project engineer with Project EM, Mr. Fink has worked with the USACE, Walla District, since 1980. He has served as project manager, technical manager and designer for a number of civil works projects for the Corps. He was assistant project engineer for construction of a fish hatchery and associated spring collection system, and technical manager for the design of a large flood control project in Fresno, California. He worked on the Environmental Restoration and Disposal Facility, the HAMMER Training Center, upgrade of the W291 BAT/AKART Water Treatment Facility, all at the DOE Hanford site. He also served as Technical Manager for the research and development of fish Surface Bypass and Collection Systems for the Lower Snake River. A Registered Professional Engineer in the state of Washington, Mr. Fink earned a B.S. in Civil Engineering from Washington State University and an M.E. in Civil Engineering with an emphasis in Hazardous Waste Management from the University of Idaho. He participated in the Leadership Development Program at Seattle University and is also trained in Geotechnical Aspects of Hazardous Toxic Waste (HTW) Sites; Seepage, Piping, and Remediation Measurement; HTW Cleanup; Personal Protection on HTW; and A-E Contracting.

Gail Bingham

An engineering consultant, Gail Bingham's recent assignments have included the Comprehensive Vitrification Project Review Team, the VitPP Value Engineering Team, the VitPP RAM Analysis, the Melter Failure Incident Analysis Team and the Silos Project Independent Review Team, all at the DOE Fernald site. He has worked for DOE Headquarters on the Federal Facility Compliance Act, DNFSB 90-2 (S/RIDs), Baseline Environmental Management Report and on the Ten-Year Plan. His previous experience includes serving as manager in Strategic Planning and in the Major Projects Department for Westinghouse Idaho Nuclear. He has a B.S. in Chemical Engineering from Oregon State University and an M.B.A. from the University of Idaho. His training also includes Cost Schedule Control System Criteria, Design Review Process, Environmental Assessment, MORT (Risk Analysis), and Construction Contract Litigation.

Scott Davis

Scott Davis is a civil engineering student at the University of Missouri - Rolla. He is a field technician for Dames and Moore and has performed as recorder on several VE studies.

Kurt Fisher

Kurt Fisher works in the Eastern Operations Office of the Office of Environmental Management in support of the DWPF at the Savannah River Site. Mr. Fisher holds a B.S. in Mining Engineering from the University of Pittsburgh, Pittsburgh, Pennsylvania. He has thirteen years of experience in general contracting and construction management as both a project engineer and project manager. Mr. Fisher joined the Department in March, 1992, and held program manager

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positions within the office of Waste Management Projects. Mr. Fisher worked with his counterparts in other Headquarters programs to develop a self-validation process for all capital construction projects. This process was implemented under his purview for all Office of Waste Management construction projects.

Gary Haddle, C.C.C.

Gary Haddle is a Certified Cost Consultant. He holds a Bachelor of Industrial Engineering Technology from Thomas Edison State College in Trenton, New Jersey. Mr. Haddle has twelve years of experience in the cost engineering field. He joined Project Time and Cost (PT&C) as a Mechanical Cost Engineer. As a project manager, Mr. Haddle has managed cost engineering projects for the USACE, the U.S. Navy, DOE and other governmental agencies and private sector owners. His responsibilities have included research on environmental and radioactive waste issues and new civil works technologies. In addition, he has managed extensive report projects involving environmental cost engineering issues. Mr. Haddle was instrumental in the development of many HTRW cost engineering initiatives, including parametric modeling with MCACES for DOE's Hanford and Savannah River Environmental Restoration Programs; the HTRW RA-WBS Standard Description; HTRW Productivity Study; and the Treatment, Storage and Disposal Facility (TSDF) Report. Mr. Haddle is currently Operations Manager of the PT&C office in Arlington, Virginia.

Timothy P. Jamison, E.I.T.

Timothy Jamison holds B.S. and M.E. degrees in Civil Engineering from Old Dominion University, Norfolk, Virginia. He has expertise in environmental consulting, technical issues in environmental restoration, and feasibility study level cost estimating. He developed an activity based cost estimate for the DOE Hanford site and participated in cost engineering functions for other DOE sites. He has several years of experience with groundwater contamination studies, remediation, water and wastewater treatment, and groundwater modeling. He has participated in a number of RCRA Corrective Action, CERCLA and state environmental projects, particularly as a cost estimator, reviewer and water resources specialist. Mr. Jamison is experienced with MCACES Gold, CORA and Life Cycle Estimating software.

Robert Kupp, P.E.

Mr. Kupp holds a degree in Chemical Engineering from Wayne State University. He is a senior engineer with Dames and Moore. Mr. Kupp is professionally licensed in New York State. He is an adjunct professor at New York Polytechnic Institute and lecturer in nuclear engineering and waste management. He has fifty years of experience with nuclear facilities, with expertise in nuclear engineering, design, safety analysis, economic analysis, low level waste facility licensing and project management. Mr. Kupp is published in nuclear engineering, design and safety, nuclear waste disposal, and the nuclear fuel cycle.

Doug Maynor

Doug Maynor joined the DOE Ohio Field Office as a Technology Support Engineer in 1994. Prior to joining DOE in 1993, Doug worked in the Chemical Processing Industry in engineering

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and operations positions. His work experience with large multi-national companies and small entrepreneurial companies included service as start-up manager of three grass-roots plants, one of which was in Brazil. He received a B.S. degree in Chemical Engineering from Virginia Polytechnic Institute and M.B.A. from Western New England College.

Laura Tate, P.E.

Since 1983, Ms. Tate has worked with the USACE, Hazardous, Toxic and Radioactive Waste (HTRW), Center of Expertise, in Omaha, Nebraska. Laura Tate is a registered Professional Engineer in the state of Nebraska. Her prior experience included serving as Industrial Wastewater Treatment Specialist for the Corps Omaha District, Design Branch, Environmental Design Section. She earned a B.S. in Chemical Engineering and an M.S. in Water Resources from the University of Nebraska. She also participated in Army Management Staff College and is trained in Design Quality Management, Value Engineering, Annual Health & Safety for HTRW Operations, Groundwater Treatment, Health & Safety at Radioactive Waste Sites, Treatability Studies, Incineration/Thermal Treatment, and Environmental Laws and Regulations.

Joseph J. Waits, P.E., C.V.S.

Joe Waits holds a B.S. degree in Civil Engineering and studied structural engineering in graduate school. He is a registered professional engineer and certified value specialist in value engineering. Mr. Waits was granted C.V.S. life status by the Society of American Value Engineers after completing fifteen years as a C.V.S. in 1995. He served with the USACE Mobile District for thirty-four years, including twenty-two years as the VE officer. He is a graduate Civil Engineer, with postgraduate studies in Structural Engineering and Computer Sciences. Mr. Waits has extensive construction field experience, having served as project engineer and resident engineer on large and complex defense facilities in the U.S. and abroad. He developed a 40-hour workshop course, which is nationally certified by the American Society of American Engineers. Mr. Waits was selected by the Department of Defense as the Army recipient of the prestigious award, Outstanding Individual in Value Engineering, in 1991.

Mark D. Wichman

Mark Wichman holds a B.S. degree in Chemical Engineering from Iowa State University and a M.S. degree in Environmental Engineering from the University of Iowa. He is currently completing post-graduate work towards a Ph.D. in Environmental Engineering at the University of Nebraska, Lincoln. Mr. Wichman has worked for the USACE, Omaha District, since January 1991. As a senior chemical/environmental engineer he was a senior design engineer on a number of highly complex groundwater treatment facilities, among these the CERCLA Wastewater Treatment Facility located at the Rocky Mountain Arsenal, Colorado, and the Bofors Nobel Groundwater Treatment Facility, located in Muskegon, Michigan. As lead environmental engineer, Mr. Wichman provided technical assistance during startup operations at a number of treatment facilities, among these the Industrial Waste Water Treatment Facility at Whiteman AFB, Missouri; the Upgrade to Waste Water Treatment Facility at Falcon AFB, Colorado; and the MIRM Groundwater Treatment Facility at Badger AAP, Wisconsin. As a chemical engineer within the Omaha District, Mr. Wichman provided technical oversight during construction

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activities associated with the District's Rapid Response Program during D&D activities at the Army Materials Testing Laboratory. Recent work activities include scoping and estimating support to the DOE Chicago Field Office in support of the EM40 and EM50 programs at Argonne National Laboratory. In addition to his work on this Project EM task, he is participating in assessments of the Ten-Year Plans for the DOE Mound, Ohio, and the Nevada Test Site.

Dave Yockman

Dave Yockman earned a B.S. in Chemical Engineering from Virginia Polytechnic Institute and State University and an M.S. in Environmental Engineering from the University of Maryland. He is knowledgeable and experienced with applying CERCLA, RCRA, DOE orders and industry practices as they pertain to chemical and nuclear facilities. Last year he was the project engineer for the Vitrification Pilot Plant. Prior to that, he spent five years at DOE Headquarters as a program manager developing environmental restoration policy, guidance, and budget in providing oversight of cleanup activities at the Fernald and Savannah River sites. He was also the EM-40 Fernald OU3 Program Manager responsible for cost, schedule, regulatory and DOE order compliance, and contractor performance. He gained experience in technology development and implementation while serving as the EM-40 liaison to EM-50 for implementing technologies. He has performed several benchmarking studies comparing DOE to private industry. Prior to working with DOE, he performed research designing, constructing and testing a micro bubble generator used for transporting oxygen and nutrients to the subsurface to stimulate microbial degradation of organic contaminants.

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Appendix C

Value Engineering Workshop Participation Matrix

Appendix C documents participants in the VE study during the workshop sessions on the specified days.

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VE Participation (March 10-21, 1997)																	
NAME	COMPANY	TELEPHONE	WORKSHOP SESSIONS														
			M	T	W	R	F	S	S	M	T	W	R	F	Intro	Pres	
Scott Davis	Dames & Moore	(913) 677-1490	X	X	X	X	X	X	X	X	X	X	X	X	X		
Nina Akgunduz	DOE - FN	(513) 648-3110	X												X	X	
Donald Paine	FDF	(513) 648-5310	X														
Sue Peterman	DOE - FN	(513) 648-3179	X													X	
Steve Fink, PE	USACE - NPW	(509) 527-7613	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ralph R. Jarboe	Dames & Moore	(981) 299-5947	X	X											X		
Dave Yockman	DOE - FN	(513) 648-3141	X		X	X	X			X	X	X	X	X		X	
Robert W. Kupp	Dames & Moore	(914) 735-1200	X	X	X	X	X			X	X	X	X	X	X		
Doug Maynor	DOE - OH	(513) 865-3986	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dennis A. Nixon	FDF	(513) 648-4800	X												X		
Tim Jamison, EIT	Project Time & Cost	(703) 351-7000		X	X	X	X	X	X	X	X	X	X	X	X		
Laura L. Tate, PE	CEMRO-HX-G	(402) 697-1490		X	X	X	X	X	X	X	X	X	X	X	X		
Michael G. Deiters	Project Time & Cost	(770) 444-9799		X	X										X		
Gail Bingham	Consultant	(208) 523-2829		X	X	X	X	X	X	X	X	X	X	X	X		
Mark Wichman, PE	CEMRO-FDF-DK	(402) 221-4354		X	X	X	X	X	X	X	X	X	X	X	X		
Mark Childs	Project Time & Cost	(803) 649-0014		X	X										X		
Kurt Fisher	DOE-HQ	(301) 903-7412		X	X	X	X	X	X	X	X	X	X	X			

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VE Participation (March 10-21, 1997)																	
NAME	COMPANY	TELEPHONE	WORKSHOP SESSIONS														
			M	T	W	R	F	S	S	M	T	W	R	F	Intro	Pres	
Gary Haddle, CCC	Project Time & Cost	(703) 351-7000			X	X	X	X	X	X	X	X	X	X			
Claude Griffin	FDF	(513) 648-4004		X											X		
Jeff Stone	FDF	(513) 648-4803		X											X		
Bob Heck	FDF	(513) 648-3051															X
Joe Waits, PE, CVS	Dames & Moore	(334) 666-5892				X	X	X	X	X	X	X	X	X			
John H. Kolts	DOE-Idaho	(208) 526-9909					X			X	X						
Samuel Wolinsky, P.E.	FDF	(513) 648-4814		X						X					X		
Tom Corder	USACE	(202) 761-5603									X						
Ed Barth	EPA	(513) 569-7669									X						
Karen Wintz	FDF	(513) 648-4059											X				
Rod Gimple	FDF	(513) 648-4842											X				
Jack Craig	DOE-FN	(513) 648-3101															X
Glenn Griffiths	DOE-FN	(513) 648-3152															X
Dave Kozlowski	DOE-FN	(513) 648-3187															X
Johnny Reising	DOE-FN	(513) 648-3139															X
Randy Janke	DOE-FN	(513) 648-3123															X
Mike Connors	FDF	(513) 648-4837	X	X	X	X	X	X	X	X	X	X	X	X	X		

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Appendix D

Value Engineering Creative Idea List

Brainstorming

The following list of ideas is in a brainstorming format without regard to feasibility. The purpose of this session was to generate as many ideas as possible without constraint to discover possible cost benefits that otherwise may be overlooked.

A - Retrieval

- A1 - Bladder in silo top, retrieval from bottom (S1&2)
- A2- Salvage pipe wrench
- A3 - Look at need for superstructure
- A4 - Belt conveyance
- A5 - Silo 3 into existing pond (pit 5)
- A6 - Mix w/contaminated soil & vacuum extrusion
- A7 - Dredge pump for 1 & 2
- A8 - Vacuum 3
- A9 - Tower crane
- A10 - Fluidize Silo 3 to retrieve
- A11 - Enclose Silo 3 with tank, remove radon
- A12 - Review need for people in/on superstructure
- A13 - Move Bridge from S4 and reuse
- A14 - Dump Houdini
- A15 - Houdini backup system
- A16 - Bottom draft radon, remove cover
- A17 - Houdini alternate
- A18 - Low tech excavation (for example, clamshell, backhoe)
- A19 - Mining approach from bottom for s1 & s2
- A20 - Remove bentonite separately and treat as cold waste
- A21 - Examine berm removal
- A22 - Tank stability without berm removal
- A23 - Reuse s1 superstructure for s2

B - D&D, Demolition

- B1 - Work with Envirocare to change waste acceptance criteria
- B2 - Decontaminate silo concrete for free release
- B3 - Reuse existing berm
- B4 - Demolish OU4 facilities under one contract at one time, single mob/demob

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C - Treatment

- C1 - Pre-treatment of toxicity characteristic leaching procedure (TCLP) materials
- C2 - Expand scope of treatment facility to handle other waste
- C3 - Expedite treatment-on-site storage for transport
- C4 - S4 for homogenizing
- C5 - Mix 1,2,3 prior to stabilization
- C6 - Homogenize 1 and 2 in separate tank
- C7 - Segmented gate process to classify waste for Envirocare
- C8 - Use sgp to remove radium
- C9 - Return to Africa
- C10 - Insitu Vitrify
- C11 - Abandon in place
- C12 - Build two large AC charcoal trains with two beds in series
- C13 - Vit monoliths in lieu of gems
- C14 - Oakridge low level waste vit program as pilot program
- C15 - Insitu solidification/stabilize
- C16 - Optimize production Vs shipping (for example, smaller facility vs. longer operation)
- C17 - Use transportable solidification vit, reuse at other site
- C18 - Insitu vit of soil below silos
- C19 - Ppre-treat 1,2,3 to allow one type of vitrification
- C20 - Evaluate continuous operation of solidification system
- C21 - Off-site treatment with vit
- C22 - Soil under s1 & 2 - pond
- C23 - Better absorption medium for radon
- C24 - Treat to minimum standards
- C25 - Use aqua set with Silo 3 (sim Envirocare) and vacuum extraction (140lb/cf density)
- C26 - Portable cementitious batch plant
- C27 - Ceramic process with harmonic compaction
- C28 - Pour activated carbon on top of box (radon)
- C29 - Design solidification plant to accept 25000 drums on-site
- C30 - Incorporate radon absorbent into formulation
- C31 - Ship to local off-site place for solidification
- C32 - Recover radium for cancer treatment
- C33 - Mine for metals
- C34 - Purchase successful system
- C35 - Locate treatment plant adjacent to silos
- C36 - Combine bentonite and contaminated soil in treatment method other than vit
- C37 - Revisit waste loading
- C38 - Ship waste to west valley for off-site treatment
- C39 - Ship some/all to Envirocare
- C40 - Produce waste form which can later be fired
- C41 - Verify successful scale up of melter
- C42 - Look at existing info onsite solidification demo (permafix)
- C43 - Verify successful vit of LL waste in world

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- C44 - Reevaluate need for NRTS
- C45 - Pressure grout inside tank and leave in place
- C46 - Mix with cement to produce soil cement and place on-site landfill, use for pet. rocks

D - Transport/Disposal

- D1 - Reexamine deep burial as opposed to shallow burial @ NTS
- D2 - Using sea/land containers for transport
- D3 - Lead for shielding
- D4 - Use Silo 3 to make cement insert and put one half in middle
- D5 - Commercial available container for SEG
- D6 - Ship using unit trains
- D7 - Reusable transport containers
- D8 - Reactivate rail spur to NTS
- D9 - Ship by rail
- D10 - ship overseas
- D11 - Piggy back transport
- D12 - On-site Resource Conservation and Recovery Act cell after stabilization
- D13 - Reexamine packaging (for example, shielded truck)
- D14 - Build new interim storage facility
- D15 - S4 for temporary storage
- D16 - Revisit on-site facilities for storage
- D17 - Make grout from Silo 3 material and dispose in Silo 4

E - Procurement

- E1 - USACE oversight
- E2 - Multiple contractor issues
- E3 - Verify ROD change requirements with cost and schedule
- E4 - Contract options for Silo 3 vendor to also remediate s1 & 2
- E5 - Fence off the site and treat as commercial NRC regulated facility
- E6 - Privatize whole facility
- E7 - Review innovative procurement strategies
- E8 - Add VE clause in all subcontracts
- E9 - Include outside independent review
- E10 - Minimize new construction
- E11 - Look at a/e strategy
- E12 - Revisit the need to meet all DOE orders
- E13 - RFP reviewed by IRT before issuance
- E14 - Contractor responsible for utilities
- E15 - Ensure funding method matches design capacity
- E16 - Delay Silo 3 RFP
- E17 - Use performance spec to economize construction/operation

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F - Other

- F1 - Scrutinize schedule estimates
- F2 - Scrutinize cost estimates
- F3 - EPA, State EPA and DOE to form a task force to expedite process
- F4 - Pursue site technology funding from DOE/EPA
- F5 - Leverage funding
- F6 - Privatization funding
- F7 - Look at PM requirements and capabilities
- F8 - Realities of funding program
- F9 - Get EPA Superfund involved in process
- F11 - Compare initial vit cost estimate to final cost at similar facility (West Valley, Savannah)
- F12 - Apply more rigorous contingency analysis
- F13 - Evaluate the influence of the stakeholders
- F14 - Review resource loading
- F15 - Evaluate changes to labor agreement
- F16 - Look at demonstration projects
- F17 - Design as a function of total project
- F18 - Develop scope of site allocation costs
- F19 - Reduce double counting of soil remediation

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Brainstorming (Revised)

The following list of ideas were prepared by screening and revising the preceding list of ideas to identify those ideas having potential for implementation. These ideas are described in more detail to enhance communication and understanding.

A - Retrieval

A1 - Radon Control - Bladder in silo top, retrieval from bottom (S1&2); enclose s3 with tank, remove radon; bottom draft radon, remove cover; build two large AC charcoal trains with two beds in series; better absorption medium for radon

A2 - Superstructure Modification - Look at need for superstructure; tower crane; review need for people in/on superstructure; move bridge from S4 and reuse; reuse s1 superstructure for s2

A3 - Waste Retrieval - Belt conveyance; dredge pump for 1 & 2; vacuum 3; fluidize Silo 3 to retrieve; bottom draft radon, remove cover; low tech excavation e.g. clamshell, backhoe; mining approach from bottom for s1 & 2; Remove bentonite separately and treat as cold waste

A4 - Robotics - Dump Houdini; Houdini backup system; Houdini alternate

A5 - Silo Integrity - Examine berm removal; tank stability without berm removal

B - D&D, Demolition

B1 - D&D - Decontaminate silo concrete for free release; demolish OU4 facilities under one contract at one time, single mob/demob; reduce double counting of soil remediation; reuse existing berm

C - Treatment

C1 - Product Facility/Interim Facility - Expand scope of treatment facility to handle other waste; design solidification plant to accept 25,000 drums on-site; optimize production vs. shipping (for example, smaller facility vs. longer operation); expedite treatment--on-site storage for transport; locate treatment plant adjacent to silos; evaluate continuous operation of solidification system; build new interim storage facility; S4 for temporary storage; revisit on-site facilities for storage

C2 - Pretreatment- S4 for homogenizing; homogenize 1 & 2 in separate tank; use aqua set with Silo 3 (sim Envirocare) and vacuum extraction (140 lb/cf density); Reevaluate need for NRTS

C3 - Separation - Segmented gate process to classify waste for Envirocare; use sgp to remove radium; recover radium for cancer treatment

C4 - Vitrification - Vit monoliths in lieu of gems; Oakridge low-level waste vit program as pilot program; use transportable solidification vit, reuse at other site; off-site treatment with vit; purchase successful system; verify successful scale up of melter; verify successful vit of low-level waste in world; revisit waste loading

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C5 - S/S - Portable cementitious batch plant; treat to minimum standards; ship to local off-site place for solidification; purchase successful system; incorporate radon absorbent into formulation; combine bentonite and contaminated soil in treatment method other than vit; revisit waste loading; look at existing info onsite solidification demo (permafix)

C6 - S/S with Volume Reduction - Ceramic process with harmonic compaction, produce waste form which can later be fired; mix with contaminated soil and vacuum extrusion

D - Transport/Disposal

D1 - Packaging - Using sea/land containers for transport; commercial available container for SEG; reusable transport containers; reexamine packaging (for example, shielded truck)

D2 - Innovative Packaging - Use Silo 3 to make cement insert and put one half in middle; pour activated carbon on top of box (radon)

D3 - Rail Shipment - Ship using unit trains; reactivate rail spur to NTS; ship by rail; piggy-back transport

D4 - Commercial Disposal - Work with Envirocare to change waste acceptance criteria; ship some/all to Envirocare

E - Procurement

E1 - Outside Procurement Involvement - USACE oversight; review innovative procurement strategies; RFP reviewed by IRT before issuance; include outside independent review; multiple contractor issues; use performance spec to economize construction/operation

E2 - Contract Options - Contract options for Silo 3 vendor to also remediate s1 & 2; minimize new construction; look at a/e strategy; revisit the need to meet all DOE orders; contractor responsible for utilities; use performance spec to economize construction/operation

E3 - Commercial Facility - Fence off the site and treat as commercial NRC-regulated facility

F - Other

F1 - Cost and Schedule Evaluation - Scrutinize schedule estimates; verify ROD change requirements with cost and schedule; ensure funding method matches design capacity; delay Silo 3 RFP; scrutinize cost estimates; apply more rigorous contingency analysis; review resource loading; design as a function of total project; develop scope of site allocation costs; look at PM requirements and capabilities

F2 - Review research and development (R&D) demonstration projects - Look at demonstration projects.

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Design Suggestions

G1 - EPA, State EPA and DOE to form a task force to expedite process

G2 - Pursue site technology funding from DOE/EPA

G3 - Leverage funding

G4 - Privatization funding

G5 - Get EPA Superfund involved in process

G6 - Evaluate changes to labor agreement

G7 - Add VE clause in all subcontracts

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Brainstorming: Basis Of Recommendations

The following list of ideas were condensed from the previous list. These ideas form the basis for the team's recommendations. This list of ideas and corresponding identifiers form the basis of ideas and the extension of ideas that evolved from the brainstorming lists and are used throughout this report.

A - Retrieval

- A1 *Radon Control* - Bladder in silo top, retrieval from bottom (S1&2); enclose S3 with tank, remove radon; bottom draft radon, remove cover; build two large AC charcoal trains with 2 beds in series; better absorption medium for radon
Waste Retrieval - Belt conveyance; dredge pump for S1&2; vacuum S3; fluidize Silo 3 to retrieve; bottom draft radon, remove cover; low-tech excavation, for example clamshell, backhoe; mining approach from bottom for S1&2; remove bentonite separately and treat as cold waste
- A2 *Superstructure Modification* - Look at need for superstructure; tower crane; review need for people in/on superstructure; move Bridge from S4 and reuse; reuse S1 superstructure for s2
Silo Integrity - Examine berm removal; tank stability without berm removal

C - Treatment

- C1 *Product Facility/Interim Facility* - Expand scope of treatment facility to handle other waste; design solidification plant to accept 25000 drums on-site; optimize production vs. shipping (for example, smaller facility vs. longer operation); expedite treatment, on-site storage for transport; locate treatment plant adjacent to silos; evaluate continuous operation of solidification system; build new interim storage facility; S4 for temporary storage; revisit on-site facilities for storage
- C4 *Vitrification* - Vit monoliths in lieu of gems; Oakridge low-level waste vit program as pilot program; use transportable solidification vit, reuse at other site; off-site treatment with vit; purchase successful system; verify successful scale up of melter; verify successful vit of low-level waste in world; revisit waste loading
- C5 *S/S* - Portable cementitious batch plant; treat to minimum standards; ship to local off-site place for solidification; purchase successful system; incorporate radon absorbent into formulation; combine bentonite and contaminated soil in treatment method other than vit; revisit waste loading; look at existing info onsite solidification demo (permafix)
- C6 *S/S with Volume Reduction* - Ceramic process with harmonic compaction, produce waste form which can later be fired; mix with contaminated soil and vacuum extruded

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D - Transport/Disposal

- D1 *Packaging* - Using sea/land containers for transport; commercial available container for SEG; reusable transport containers; reexamine packaging (for example, shielded truck)
- D2 *Innovative Packaging* - Use Silo 3 to make cement insert and put one half in middle; pour activated carbon on top of box (radon)
- D3 *Rail Shipment* - Ship using unit trains; reactivate rail spur to NTS; ship by rail; piggy back transport
- D4 *Commercial Disposal* - Work with Envirocare to change waste acceptance criteria; ship some/all to Envirocare

E - Procurement

- E1 *Outside Procurement Involvement* - USACE oversight; review innovative procurement strategies; RFP reviewed by IRT before issuance; include outside independent review; multiple contractor issues; use performance spec to economize construction/operation
- E2 *Contract Options* - Contract options for Silo 3 vendor to also remediate s1 & 2; minimize new construction; look at a/e strategy; revisit the need to meet all DOE orders; contractor responsible for utilities; use performance spec to economize construction/operation

F - Other

- F1 *Cost and Schedule Evaluation* - Scrutinize schedule estimates; verify ROD change requirements with cost and schedule; ensure funding method matches design capacity; delay Silo 3 RFP; scrutinize cost estimates; apply more rigorous contingency analysis; review resource loading; design as a function of total project; develop scope of site allocation costs; look at PM requirements and capabilities
- F2 *Review R&D Demonstration Projects* - Look at demonstration projects

Design Suggestions

- G1 EPA, State EPA, DOE to form a task force to expedite process
- G2 Pursue site technology funding from DOE/EPA
- G3 Leverage funding
- G4 Privatization funding
- G5 Get EPA superfund involved in process
- G6 Evaluate changes to labor agreement

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- G7 Add VE clause in all subcontracts
- G8 *Robotics* - Dump Houdini; Houdini backup system; Houdini alternate
- G9 *D&D* - Decontaminate silo concrete for free release; demolish OU4 facilities under one contract at one time, single mob/demob; reduce double counting of soil remediation; reuse existing berm

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Priority Rating And Assignment

The priority rating was established by having each member rank the recommendation 1 through 10 (10 being the highest) and then averaging the votes. Team personnel were then assigned to each idea to evaluate and prepare a VE recommendation.

ID #	Title	Priority Rating	Assignment
A1	Radon Control & Waste Retrieval	5	Laura, Doug
A2	Superstructure Modification & Silo Integrity	6	Steve, Tim
A4 (DS)	Robotics	1	
B1 (DS)	D&D	3	
C1	Production facility/Interim storage	8	Laura, Bob
C2 (Drop)	Pretreatment	3	
C3 (Drop)	Separation	2	
C4	Vitrification	8	Bob
C5	S/S	9	Gary, Kurt
C6	S/S with Volume Reduction	6	Doug
D1	Packaging	7	Mark, Gary
D2	Innovative Packaging	6	Gale, Kurt
D3	Rail Shipment	8	Tim, Steve
D4	Commercial Disposal	6	Tim
E1	Outside Procurement Involvement	7	Gale, Steve
E2	Contract Options	8	Gale, Kurt
E3 (Drop)	Commercial Facility	1	
F1	Cost & Schedule Evaluation	9	Gary
F2	Review R&D Demonstration Projects	5	Doug

Drop - The idea was dropped from the recommendation list and was not further developed.

DS - The idea was not further developed as a recommendation, but was incorporated as a design suggestion.

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Appendix E

Value Engineering Proposals

This section contains the team write-ups of all proposals identified during the VE study. Each proposal is marked by a unique identification number. This is the same identification number found attached to the idea from which the proposal was developed. These identification numbers are used throughout the report to uniquely refer to a given proposal and corresponding idea.

Acceptance of Single Issues

Each proposal was developed around a single issue. This simplified the acceptance or rejection of the proposal and gave added flexibility to implementing the proposals, in that several single issue proposals could be combined as needed to achieve a desired result. When evaluating a proposal, one is encouraged to look at each part of the proposal on an independent basis. There is no need to discard a proposal in total because one part of the proposal is unacceptable. A proposal can be accepted in part or accepted with a specified partial modification.

Usually all proposals cannot be simultaneously accepted or combined. While some proposals can be simultaneously accepted and combined, others cannot. This is because some proposals are mutually exclusive of one another, and accepting one proposal could automatically preclude accepting certain others.

Summary of Proposals

The following table, Summary of Proposals, offers a convenient overview of all proposals along with economic data associated with each. As mentioned earlier, all proposals cannot be accepted together. For this reason, the reader is cautioned regarding summation of the cost benefits column. Because some proposals are mutually exclusive of others, the addition of all cost benefits to obtain a sum total of cost benefits will produce a fictitious and erroneous amount.

Organization of Proposals.

The proposals presented on the following pages are organized alphabetically by function identifier and numerically within each function. The sequence of functions are as follows:

<u>Function Identifier</u>	<u>Function</u>
A.....	Retrieve Waste
B.....	D&D, Demolition
C.....	Treat Waste
D.....	Transport/Disposal of Waste
E.....	Procurement

000051

FORM: 30 DEC. 1996

SUMMARY OF PROPOSALS - PAGE 1

Project: Critical Analysis of OU4 Vitrification and Potential Alternatives

Location: Fernald, Hamilton County, Ohio

Study Date: March 10-21, 1997

Description		Present Worth Amount				
ID #	Recommendation	Original Design	Recommendation	Resulting Cost Benefits (or Cost)	O&M Benefits (or Cost)	Total LCC Benefits (or Cost)
A1.1	Minimize water use	29,411,000	6,586,000	22,825,000	0	22,825,000
A1.2	Emissions control, Alternative 3					
A2.1	Construct one re-usable superstructure and appurtenances for both Silos 1 & 2	8,186,471	5,162,800	3,023,671	0	3,023,671
A2.2	Use tower crane instead of two superstructures for waste retrieval	8,086,106	1,947,969	6,138,137	0	6,138,137
C1.1	Treatment Consideration of Silos 1, 2 and 3	96,700,000	75,000,000	21,700,000	0	21,700,000
C1.2	Treat Contents - processing rate					
C4.1	"Gems" to "monolith"	0	0	0	20,000,000	20,000,000
C4.2	Design, purchase and use a "proven" melter					
C5.1	Pack waste - solidification	237,788,000	105,683,000	132,105,000	0	132,105,000
C5.2	Waste packaging - control radon					

LEGEND: LCC = life-cycle cost = first cost + all use-costs over the life of the project.

LCC benefits = first cost benefits (or adds) + all O&M cost benefits (or adds) over the life of the project.

Note: benefits in parenthesis "()" = negative benefits = added cost

**Fernald Environmental Management Project
CA of OU4 Vitrification and Potential Alternatives**

FORM: 30 DEC. 1996

SUMMARY OF PROPOSALS - PAGE 2

Project: Critical Analysis of OU4 Vitrification and Potential Alternatives

Location: Fernald, Hamilton County, Ohio

Study Date: March 10-21, 1997

Description		Present Worth Amount				
I.D. #	Recommendation	Original Design	Recommen- dation	Resulting Cost Benefits (or Cost)	O&M Benefits (or Cost)	Total LCC Benefits (or Cost)
C5.3	Reduce Volume - Alternative 2	65,244,000	61,963,000	3,281,000	0	3,281,000
	Reduce Volume - Alternative 3	226,520,000	210,025,000	16,495,000	0	16,495,000
C5.4	Mix waste concrete - stabilization/solidification	133,900,000	60,227,000	73,673,000	0	73,673,000
D1.1	Waste packaging/shielding	197,540,000	81,542,000	115,998,000	0	115,998,000
D2.1	Enclose waste - stabilization/solidification	21,594,000	3,884,000	17,710,000	0	17,710,000
D4.1	Commercial disposal	5,419,008	1,801,068	3,617,940	483,840	4,101,780
E1.1	Innovative procurement	647,000,000	323,500,000	323,500,000	0	323,500,000
E1.2	Independent reviews of RFP					
E2.1	Improve contracting philosophy	102,473,000	77,811,000	24,662,000	0	24,662,000
E2.3	Design/construct plants - stabilization/solidification					
E2.4	DOE orders and standards					
E2.5	Use subcontractor and existing facilities	647,000,000	388,200,000	258,800,000	0	258,800,000

LEGEND: LCC = life-cycle cost = first cost + all use-costs over the life of the project.

LCC benefits = first cost benefits (or adds) + all O&M cost benefits (or adds) over the life of the project.

Note: benefits in parenthesis "()" = negative benefits = added cost.

Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

FORM 20 DEC 1996

PROJECT: Critical Analysis of OU4 Vitrification and Potential Alternatives

Page 1 of 15

LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997

IDENTIFICATION NUMBER: A1.1

FUNCTION OF COMPONENT BEING CHANGED: Retrieve Materials

DESCRIPTIVE TITLE OF RECOMMENDATION: Minimize Water Use

ORIGINAL DESIGN:

Install superstructure, cut hole in silo dome, insert pump and robotic assistant, design and install new radon capture system, and then add water to dilute to 20% solids for pump out from the top.

RECOMMENDED CHANGE:

Foam top of tank above the bentonite clay cap with polyurethane to provide a positive seal and prevent radon escape from the top. The polyurethane foam will also be engineered to provide additional structural support for the tank top.

Cut hole in either the side or bottom of the silo and if possible remove the sludge without addition of any water. If equipment to remove the waste as is cannot be found, then minimize the amount of water added to the barest minimum. Process the sludge using either vitrification or cementation at the highest possible solids content rather than processing as a 30 to 40% solids slurry.

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Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: A1.1

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SUMMARY OF COST ANALYSIS			
	First Cost	O & M Costs (Present Worth)	Total LC Cost (Present Worth)
ORIGINAL DESIGN	29,411,000	0	29,411,000
RECOMMENDED DESIGN	6,586,000	0	6,586,000
ESTIMATED SAVINGS OR (COST)	22,825,000	0	22,825,000

ADVANTAGES:

- Provides cost savings by eliminating the need to treat the added water.

DISADVANTAGES:

- Foaming in headspace will result in additional waste for disposal.
- Requires a more in-depth engineering study to identify a viable dry retrieval system.
- Requires more extensive structural analysis of the silos and possible installation of additional support.
- Requires a risk analysis be performed evaluating the structural risk of entering dome roof versus cutting through silo wall.
- Not supported by VE team because bottom retrieval is doubtful using the suggested retrieval equipment, and concern for silo integrity based on past engineering studies.
- In 1988, the site investigated the application of polyurethane foam in the silo headspace and rejected it on the basis of fire hazard. Follow-up discussions with foam vendors by the VE team determined that concerns for foam as a fire hazard no longer exist due to improved recipes and application procedures.

000055

VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: A1.1

Page 3 of 15

JUSTIFICATION:

The sludge in Silos 1 and 2 was originally placed in the silos by dumping the sludge from drums into a slurry tank where water was added and the dilute slurry was pumped into the silo. Once in the silo, the solids were allowed to settle and the water was decanted off. The material now contains about 30% water and 70% solids.

The present design calls for removing the waste from the silos as a 20% slurry by lowering a pump (having high pressure water cutting nozzles) in through the top of the silo and then cutting/pumping the waste until the silo is empty. A robotics device is being developed to push waste to the pump, remove obstacles, and perform other tasks.

In order to carry out this concept, a superstructure will be built to span each silo in order to cut a 6 foot diameter hole in the top so that a pump can be installed to remove the waste by slurry. Because the bentonite cap will be breached, and the top has been opened, a new radon system will be installed to capture the released radon on activated carbon. The activated carbon then becomes a mixed low level waste.

The 20% slurry will be pumped against gravity over the top of the tank to a thickener where it is estimated that 40% solids slurry can be developed to feed either the vitrification or cementation process. Every pound of water not removed from the slurry during the thickening and recycling process must either be evaporated if vitrification is used or must be solidified. In either case, adding water will be an expensive way to solve the basic function of getting the sludge out of the silos.

Using the attached three page report by Rod Gimpel (12/10/96) as a basis for calculations, it can be shown that in order to convert the 70% solids into a 40% slurry and then cement it, for each 100 pounds of dry silo waste, you must add an additional 11.4 pounds of water and 25.75 pounds

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VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: A1.1

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JUSTIFICATION (continued):

or solids (cement, flyash, clay, and sand). If the slurry is reduced to 30 wt% solids, then for each 100 pounds of dry silo solids, and extra 99 pounds of water and 222.5 pounds of solids are required.

If the extra water, requiring extra solids, is converted to cement using the recipe presented to the Independent Review Team (IRT), and if the cement has a density of 115 pounds / cubic foot, then an extra 70,000 cubic feet of concrete will be made using a 40% slurry and an extra 605,000 cubic feet will be produced with a 30% slurry.

In addition to the cost of extra concrete, flyash, etc., the major cost associated with the slurry concept is that required to box, ship, and bury the extra volume produced.

Instead of building an elaborate system to add water to slurry the waste, it is recommended that the concept be reengineered to remove the material with little or no addition of extra water. By removing the sludge from the bottom side of the silo using either an auger, cement pump, or other solids handling equipment, a minimum of \$20M can be saved.

000057

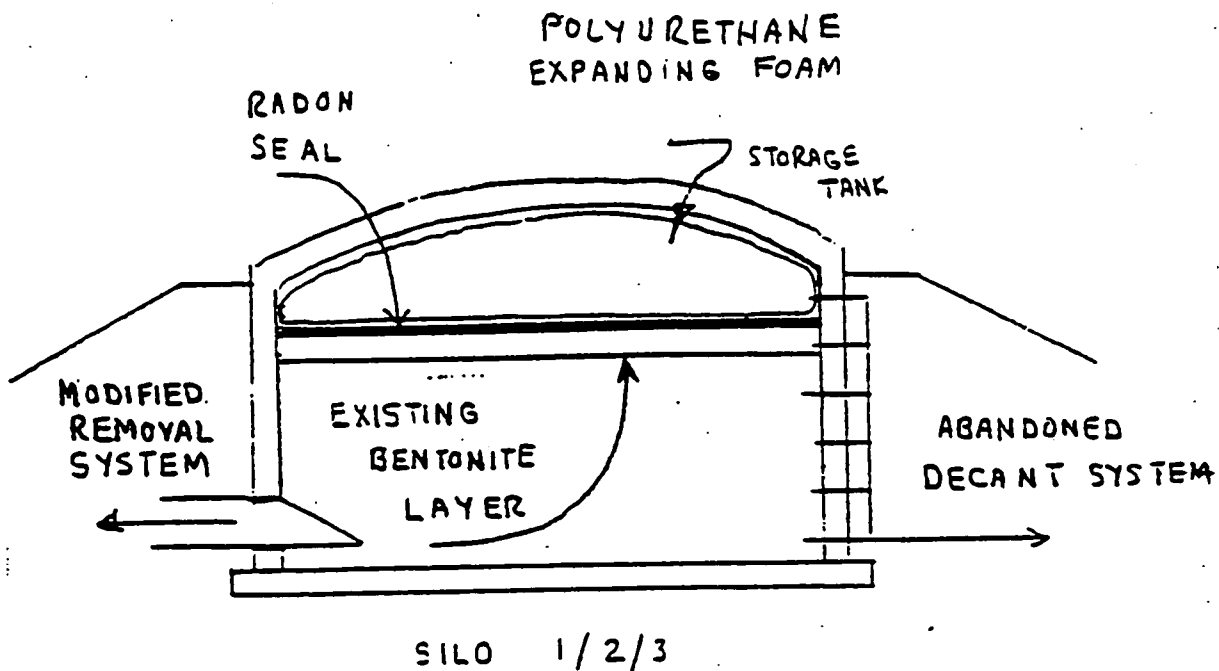
VALUE ENGINEERING RECOMMENDATION

SKETCH OF RECOMMENDED DESIGN

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IDENTIFICATION NUMBER: A1.1

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PROPOSED SILO
RADON CONTROL PLAN

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VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: A1.1

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Rod F. Gimpel
 12/10/96

Determining Solidification Stabilization Quantities for Silos 1 and 2

Fernald Silo In Situ Waste Quantities:

Silo 1 waste residues	7,642
Silo 2 waste residues	<u>6,620</u>
	14,262

Silo 1 bentonite cap	630
Silo 2 bentonite cap	<u>555</u>
	1,118

Total	15,447 (10,813 dry)
-------	---------------------

Treated Waste Amount:

Solidification stabilization formulas developed for Silos 1 and 2 are given in Tables 3-7 and 3-8 within "Treatability Study Report Operable Unit 4" dated March 1993. The following solidification calculations are based on Run No. 2 as shown in Table 3-7 of the treatability study. The treatability formulas were based on "mined" in situ moistures. The average moisture was assumed to be 30 wt% in the treatability study. However, plans are to remove the wastes as a slurry during remediation of the silos. The remedial slurry system is assumed to handle and deliver a feed with 30 to 40 wt% solids.

Table 1 shows the Run No. 2 formula adjusted for a slurry feed system handling 40 wt% solids. Table 2 shows the same data adjusted for a slurry feed system handling 30 wt% solids. The 30 wt% solids handling may be the more realistic expected value. The OU4 Pilot feed system handled an average of 34 wt% solids during Campaign 2 and during Campaign 4, thus far, it has handled approximately 35 wt% solids. However, the 34 and 35 wt % solids contain 32 % (11 wt% absolute) soluble compounds (potassium carbonate, potassium nitrate, lithium carbonate, sodium carbonate, sodium nitrate, and boric acid). Therefore, the effective wt% solids physically handled by the system is less - it would be 23 and 24 wt% if all the soluble materials were dissolved in the water. Also, bentonite has not been used in Campaigns 2 or 4 thus far. Its presence may lower the wt% solids handling capacity of the feed system.

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Table 1
 Run No. 2 with 40 wt%

Component	Treatability Report Run 2 Formula, lbs	Slurry Feed 40 wt% Solids, lbs	Run 2 Formula Adjusted, lbs	Run 2 Formula Adjusted 100 lbs basis, lbs
Waste (dry basis)	70	70	70	100
Type 2 portland cement	68		73.61	105.16
Type F flyash	68		73.61	105.16
Attapulgitc	6		6.49	9.27
Clinoptilolite	6		6.49	9.27
Water	97 (30 from waste)	105	105	150
Sand*	--		5.8	8.29
Total	315	175	341	487.15
wt % moisture	30.8	60	30.8	30.8

Stabilized waste produced = 54,000 tons. Bulking factor = 500 wt%.

*Sand is shown because it is inert. One of the other components possibly could be used.

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VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: A1.1

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Table 2
 Run No. 2 with 30 wt%

Component	Treatability Report Run 2 Formula, lbs	Slurry Feed 30 wt% Solids, lbs	Run 2 Formula Adjusted, lbs	Run 2 Formula Adjusted 100 lbs basis, lbs
Waste (dry basis)	70	70	70	100
Type 2 portland cement	68		116.6	166.57
Type F flyash	68		116.6	166.57
Attapulgitc	6		10.29	14.7
Clinoptilolite	6		10.29	14.7
Water	97 (30 from waste)	166.33	166.33	237.61
Sand*	—		49.89	71.27
Total	315	233.33	540	771.42
wt % moisture	30.8	70	30.8	30.8

Stabilized waste produced = 83,000 tons. Bulking factor = 750 wt%.

*Sand is shown because it is inert. One of the other components possibly could be used.

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TO 40 WT %

$$(25.75 \text{ lbs SOLIDS}) \quad \frac{10,813 \times 2000}{100} = 5,569,000 \text{ SOLID}$$

$$11.4 \text{ lbs H}_2\text{O} \quad = 2,465,000 \text{ H}_2\text{O}$$

8,034,000

TO 30 WT %

$$(2225 \text{ lbs SOLIDS}) = \frac{1}{100} \times = 48,118,000$$

$$99 \text{ lbs H}_2\text{O} = \frac{1}{100} \times = 21,410,000$$

69,528,000

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ASSUME AVE COST OF CEMENT, FLYASH,
 CLAY = \$ 50/TON

ASSUME AVG DENSITY OF EXTRA
 CONCRETE f ROD U CBD IS \$ 115 lbs/ft³

(a) 40 % SOLIDS

$$\left(\frac{5.569 \text{ M lbs}}{2000 \text{ lbs/TON}} \right) (\$150 \text{ TON}) = \underline{\underline{\$139,200}}$$

$$\frac{8,034,000 \text{ lbs}}{115 \text{ lbs/ft}^3} = \underline{\underline{69860 \text{ ft}^3}}$$

(g) 30 % SOLIDS

$$\left(\frac{48,118}{200} \right) (\$150) = \underline{\underline{\$1,203,000}}$$

$$\frac{69,528,000}{115} = \underline{\underline{604,600 \text{ ft}^3}}$$

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COST TO BOX, SHIP, AND BURY

⑨ 40 % SLURRY

$$\left(\frac{8,034,000}{2000} \right) \left(\$ 2,727/\text{TON} \right) = \underline{\underline{\$ 10,954,000}}$$

⑨ 30 % SLURRY

$$\left(\frac{69,528,000}{2000} \right) \left(\$ 2,727 \right) = \underline{\underline{\$ 94,801,000}}$$

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Aaron L. Long, Jr.

Urethane Foam Specialists

16679 Stocker Ridge Road

Newcomerstown, Ohio 43832

Phone: 614-498-8424

Fax: 614-498-7655

Personnel are currently trained (good for a year). This would save some money

On a small job bases we were quoted \$1.5/lb for material with an assumed density of 2 lbs/ft³. Labor was quoted at \$50/hour (2 men required). For our demo he filled about 120 ft³ in an hour.

Round trip transportation for equipment \$400.

Living expenses about \$100/day/individual (2 men required).

Special mixing gun \$3,095

I called Aaron to get his input. He had a lot of questions and requested the following:

- 1- Sketch of the silos showing the following:
 - "Cross-sectional view showing dimensions and distance to clay
 - openings and their size
 - Thickness of both the waste and clay layers
- 2- How are you going to remove waste?
- 3- What do you want to have happen to the foam as you remove the waste?
- 4- What happens to the clay layer as you remove the waste?
- 5- Would you be interested in a solid plastic product that goes in as a liquid then sets up? It is used in hazardous waste land fill.
- 6- You could use a combination of both the plastic and foam.

000065

VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: A1.1

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Work Element F

In January, the foam void filling demonstration was completed. The void filling was conducted by Urethane Foam Specialists out of Columbus Ohio.

The polyurethane foam used in this demonstration was produced by combining (in predetermined proportions based on the foam's intended use) FE 30CA; Polymeric diisocyanate (MDI); the catalyst, and FE 6329; Polyol Blend, Tertiary Amine w/ Silicone Surfactant; the foaming agent. The foam when injected is in the form of a liquid. Shortly after being injected, the liquid starts to expand into a "foam". The speed at which the liquid/foam expands can be controlled by the temperature of the liquid which is set through the process control unit. The foam in its liquid phase is injected in stages. This allowed the liquid/foam to expand to its maximum extent before additional liquid is added.

The physical properties (i.e., density and compressive strength) of the foam can be varied over a wide range by changing the ratio of its two components as well as its starting temperature. For this demonstration the foam's most important property was its compressive strength. It was specified that the foam have a compressive strength of 15 psi in order to ensure that at no time the minimal compressive strength does not drop below 10 psi which is the minimum compressive strength required by the FEMP's on-site disposal facility's waste acceptance criteria. Compressive strengths of up to 50 psi can be achieved with polyurethane foams.

This technology demonstration was conducted in Building 308 which was located southeast of Building 1A. The process started when the technology provider parked its truck adjacent to the Building 308. The truck contained a drum of both the catalyst and surfactant as well as the process control unit which controlled both the mixing ratio of the two foam components and their temperature. Next a hose (which was wrapped to prevent its contamination) was run into Building 308. Attached to the end of the hose was the mixing gun. The two foam generating components are kept separate until they are near the exit of the mixing gun at which point they are mixed.

During the demonstration the air in Building 308 was continuously monitored for MDI. The first action level was set at 5 ppm at which point the observers in Building 308 would have to don respirators. At 20 ppm everyone would have to leave Building 308 until ventilation of Building 308 lowered the concentration of MDI to acceptable levels. With only one exception, the MDI monitor reading was zero. For an instant the monitor did register a reading of 2 ppm. Since the monitor did drop back to zero and remain there, it was not known if it was a true reading or a spurious reading.

The two components to be foam filled were placed horizontally on the floor of Building 308. These two components (vessels) were identical with each having a conical bottom, two baffle plates in the lower third of the vessel, three openings with attached hatch covers which could be latched closed, and a six inch pipe coming off the top of the component with a 90 degree bend. This pipe was cut about 6 inches downstream of the bend. Except for the three openings with covers, all other openings were sealed with duct tape.

The technology provider was able to successfully fill between the two baffle plates (this was confirmed through visual observation). The pipe coming off the top of the vessel was also filled. This was verified by pushing against the duct tape used to seal the end

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OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: A1.1

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of the pipe foam filling of the components was performed in a manner that resulted in the formation of a depression in the area of each opening. This depression was then partially filled with the liquid foam and the cover then closed and tightened down. As the liquid expanded, it forced foam into any opening no matter how small. Eventually the force on the closed cover from the expanding liquid foam was so great that foam was forced out between the cover-component seating area. This method of foaming provided added confidence that the void was filled to the greatest extent possible.

This demonstration involved void filling of two components each having an internal volume of about 60 cubic feet. Filling of the two components with foam took about an hour involving four laborers for the demonstration. It is doubtful four would be needed under a routine application. Demobilization simply involved cleaning the outside of the transfer hose (removing the protective wrap) and surveying the truck before exiting the site. The total demonstration took no more than two and one-half hours for mobilization, void filling, and demobilization.

Should this technology replace equipment segmenting, it is expected that components requiring void filling, would be moved to a central staging area where a large scale void filling effort would be conducted. An option which has not been evaluated, is that the void filling be conducted in the on-site disposal facility (OSDF). This option would simplify material handling concerns and eliminate "clean up" efforts.

Specifics related to equipment performance, the demonstration data, and the life-cycle cost analysis for this technology are provided in the Detailed Technology Report prepared for this technology.

FOAM VOID FILLING

- Void filling two tanks with a total volume of 120 cubic feet - 10 man-hours* (2.5 hours X 4 individuals)
- Add cost to remove components from building and transfer to the demonstration location
- Add cost for void filler
- Added costs incurred when placing the full components in the OSDF.
- This is a conservative estimate. The actual time spent will be determined from the data package. Also under a situation where a large quantity of tanks were being filled at one time, this production rate should be improved as a result of the mobilization/demobilization time representing a much smaller portion of the total time required.

SEGMENTATION

- Segmenting four tanks with a total volume of approximately 690 cubic feet - 328 man-hours
- Add cost of acetylene and oxygen
- Add cost of lead paint stripper

000067

VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: A1.1

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ALTERNATIVE COST

- 1) FOAM HEADSPACE IN CONCRETE SILOS
WITH POLYURATHANE TO
CONTAIN RADON

BASIS: 1) FOAM COSTS \$ 2.00/lb

2) ~~1 lb~~ FOAM DENSITY = 2 lbs/ft

3) TOTAL HEADSPACE IN TWO SILOS

IS ~~86,000~~ 86,000 ft³

$$\left(\frac{86,000 \text{ ft}^3}{2 \text{ lbs/ft}^3} \right) (\$2.00/\text{lb}) = \$86,000$$

- 2) PERFORM ENGINEERING ANALYSIS
AND DESIGN BOTTOM RETRIEVAL
SYSTEM ~ \$ 1M

- 3) PURCHASE AND INSTALL RETRIEVAL
SYSTEM ~ \$ 5M

- 4) D&D EQUIPMENT \$ 0.5M

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FORM 20 DEC 1996

PROJECT: Critical Analysis of OU4 Vitrification and Potential Alternatives

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LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997

IDENTIFICATION NUMBER: A1.2

FUNCTION OF COMPONENT BEING CHANGED: Control Radionuclide Emissions

DESCRIPTIVE TITLE OF RECOMMENDATION: Emissions Control, Alternative 3

ORIGINAL DESIGN:

Two new emissions control systems were included in the original design. The more complex system was for treatment of process emissions from vitrification of the contents of Silos 1 and 2. The simpler system was for control of emissions from untreated material stored in Silo 1. In addition, the site plans to renovate the existing Silos 1 and 2 radon system to reduce worker exposure during work near the silos prior to treatment.

RECOMMENDED CHANGE:

The VE team proposes that a single, simplified emissions control system be used for treating fugitive emissions from the solidification/stabilization system and emissions from untreated and treated materials awaiting transportation.

ADVANTAGES:

- More reliable than the original design.
- Equal to original design in the removal of radionuclides from the air stream.

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VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: A1.2

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DISADVANTAGES:

- Requires a change to the Record of Decision (ROD).
- Not compatible with emissions from a vitrification system.

JUSTIFICATION:

The original system was designed for emissions from a vitrification system. The proposed design is a conventional design for treatment of emissions at near ambient conditions.

000070

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 OU4 Vitrification and Potential Alternatives

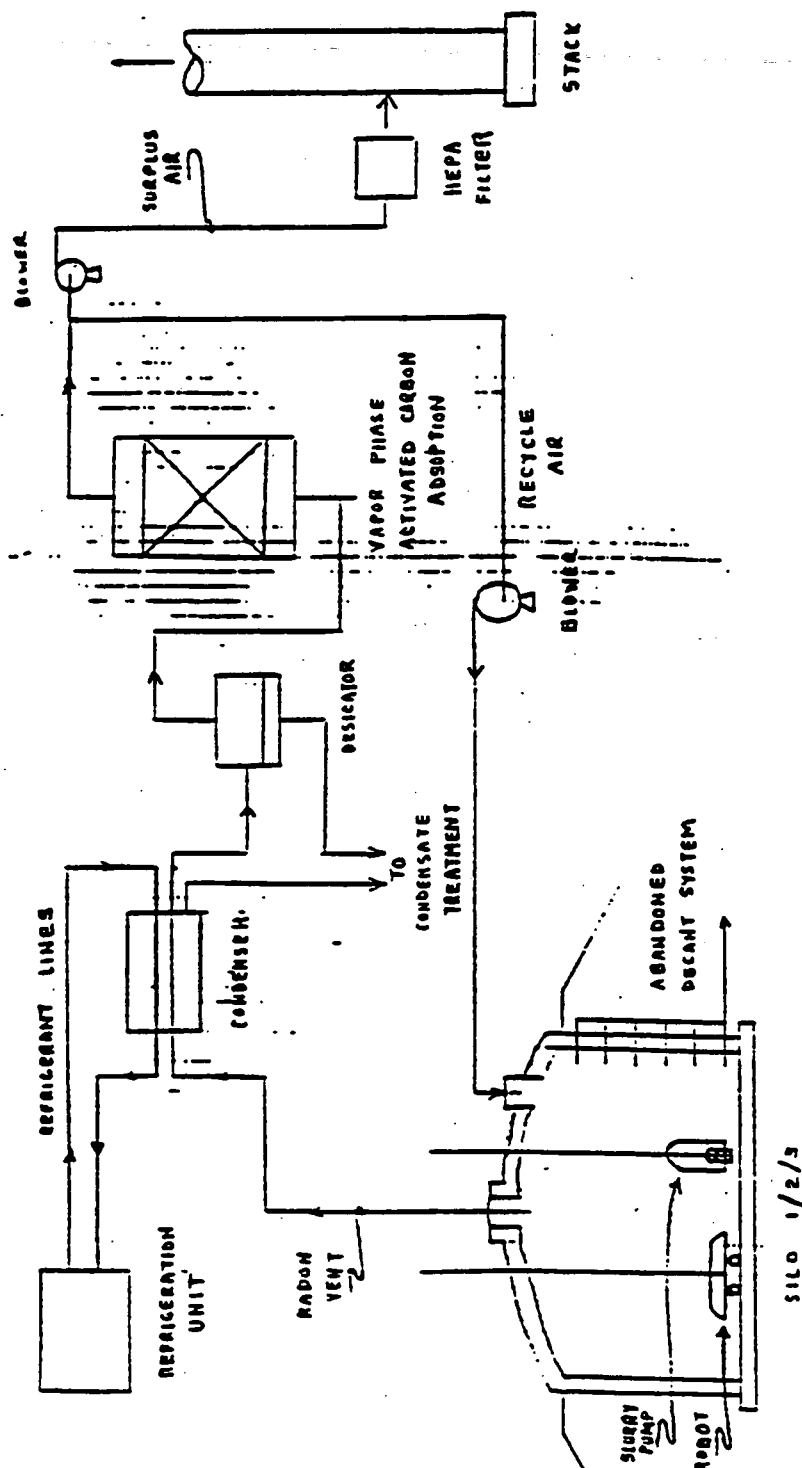
VALUE ENGINEERING RECOMMENDATION

FORM 20 DEC 1966

SKETCH OF ORIGINAL DESIGN

IDENTIFICATION NUMBER: A1.2

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CURRENT SILO RADON CONTROL PLAN

000071

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Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

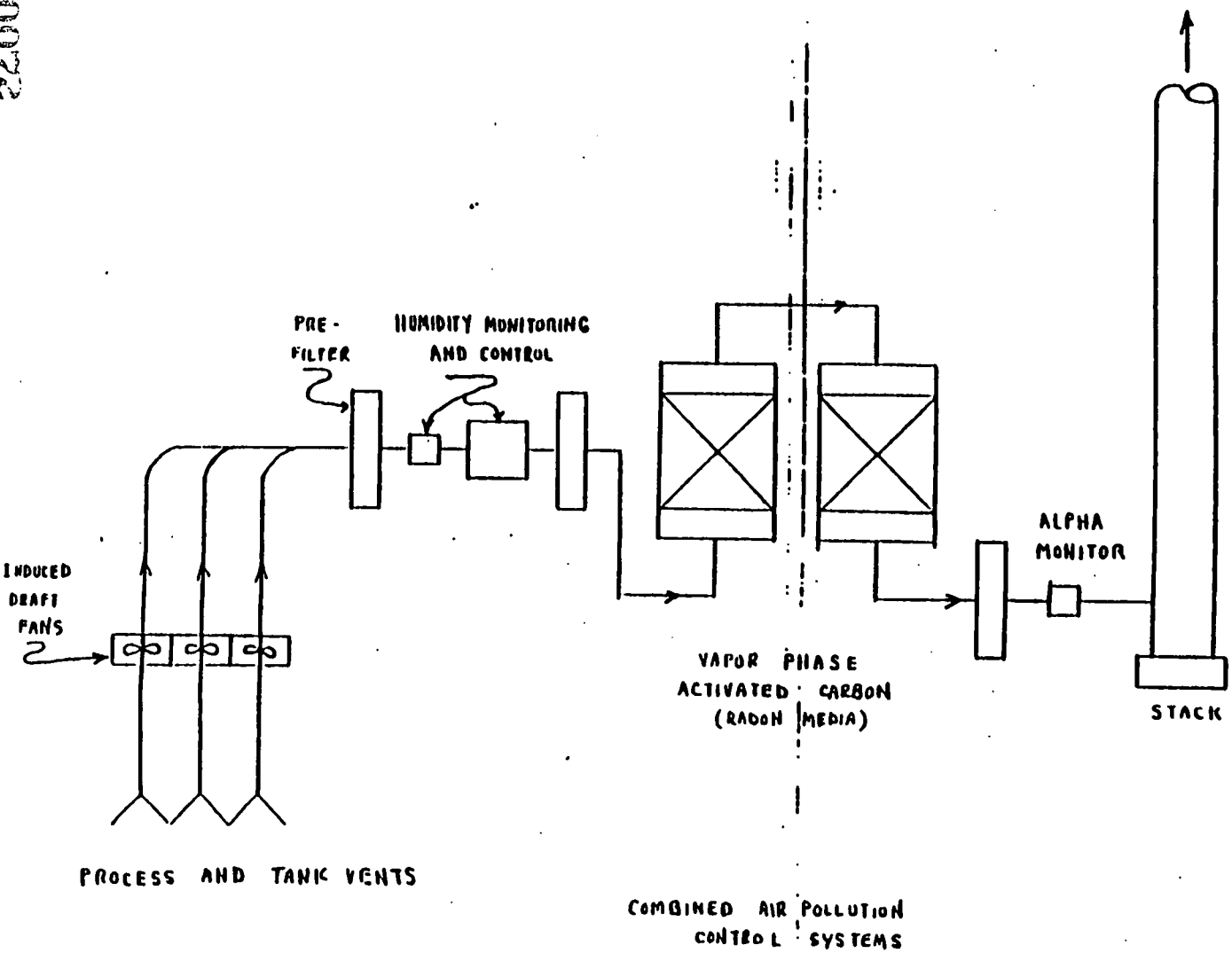
VALUE ENGINEERING RECOMMENDATION

FORM 20 DEC 1986

SKETCH OF ORIGINAL DESIGN

IDENTIFICATION NUMBER: A1.2

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OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

FORM 20 DEC 1996

PROJECT: Critical Analysis of OU4 Vitrification and Potential Alternatives

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LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997

IDENTIFICATION NUMBER: A2.1

FUNCTION OF COMPONENT BEING CHANGED: Remove Waste

DESCRIPTIVE TITLE OF RECOMMENDATION: Construct one re-usable superstructure and appurtenances for both Silos 1 and 2

ORIGINAL DESIGN:

The OU4 Conceptual Design Plan for Residue Retrieval System for the Fernald Residues Vitrification Plant calls for alternating the waste retrieval between Silos 1 and 2 in 10 foot increments. This approach allows for excavation of the surrounding berm as the silos are drained, which is desired to ensure the safety of the silo structures. This approach requires the construction of two superstructures and appurtenances, one for each of Silos 1 and 2.

RECOMMENDED CHANGE:

It is proposed that the silo material retrieval be accomplished completely on one silo at a time. This will reduce the need for superstructures and appurtenances from two to one, which can be re-used. It appears that as one silo is drained, the berm can be lowered from around the silo with only minimal encroachment on the adjacent silo. The excavation concept is shown in the attached sketches. By following the proposed berm excavation sequence around one silo as it is drained, the silo structural integrity will be maintained.

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OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: A2.1

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SUMMARY OF COST ANALYSIS			
	First Cost	O & M Costs (Present Worth)	Total LC Cost (Present Worth)
ORIGINAL DESIGN	8,186,471	0	8,186,471
RECOMMENDED DESIGN	5,162,800	0	5,162,800
ESTIMATED SAVINGS OR (COST)	3,023,671	0	3,023,671

ADVANTAGES:

- Cost saving due to the elimination of one superstructure, and appurtenances.
- Reduces disposal requirements of superstructure and equipment at the completion of remediation.
- Allows re-use of nearly all silo retrieval equipment for both silos.
- Allows lessons learned on first silo remediated to be implemented on the second silo.

DISADVANTAGES:

- Interruption of silo remediation would occur during time when superstructure and appurtenances are being relocated.
- Interruption of waste retrieval because of equipment failure would require immediate corrective action; immediately switching waste retrieval to the other silo would not be possible.

JUSTIFICATION:

The present design (Sketch 1) calls for construction of redundant retrieval systems. This is primarily due to the questionable structural integrity of the silos, which requires the surrounding

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Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: A2.1

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JUSTIFICATION (continued):

berm to be lowered concurrently with the waste retrieval from within the silos. An approach has been identified that allows for complete remediation of one silo at a time and eliminates the need for redundant superstructures and appurtenances. The documentation indicates that the soil is stable when excavated at a 1 vertical to 2 horizontal slope (Sketches 2-6). The waste retrieval will begin on Silo 1. The retrieval will proceed thru Zone A, resulting in about 7 feet of drawdown within the tank. Berm excavation can be performed using a 1V:2H slope between the silos. The top of cut will daylight the top of berm at 14 feet from Silo 1, and 26 feet from Silo 2. Retrieval of waste thru Zone B will proceed lowering the waste level in the tanks by 8 feet. The berm will again be lowered to match the tank waste level. Continuing with a 1V:2H excavation slope between the silos, the excavation catch point from Silo 1 will extend to 30' from Silo 1, 10 feet from Silo 2. Waste retrieval can then proceed through Zone C to the bottom of the tank. However, the berm between the two silos will not be removed at this time.

After cleanup of Silo 1 is complete, the silo superstructure will be moved from Silo 1 to Silo 2, and retrieval of Silo 2 waste will proceed similar to Silo 1. As Silo 2 is drained, the berm can be lowered as required. Once both tanks are drained the berm and silos can be demolished and disposed in an approved manner.

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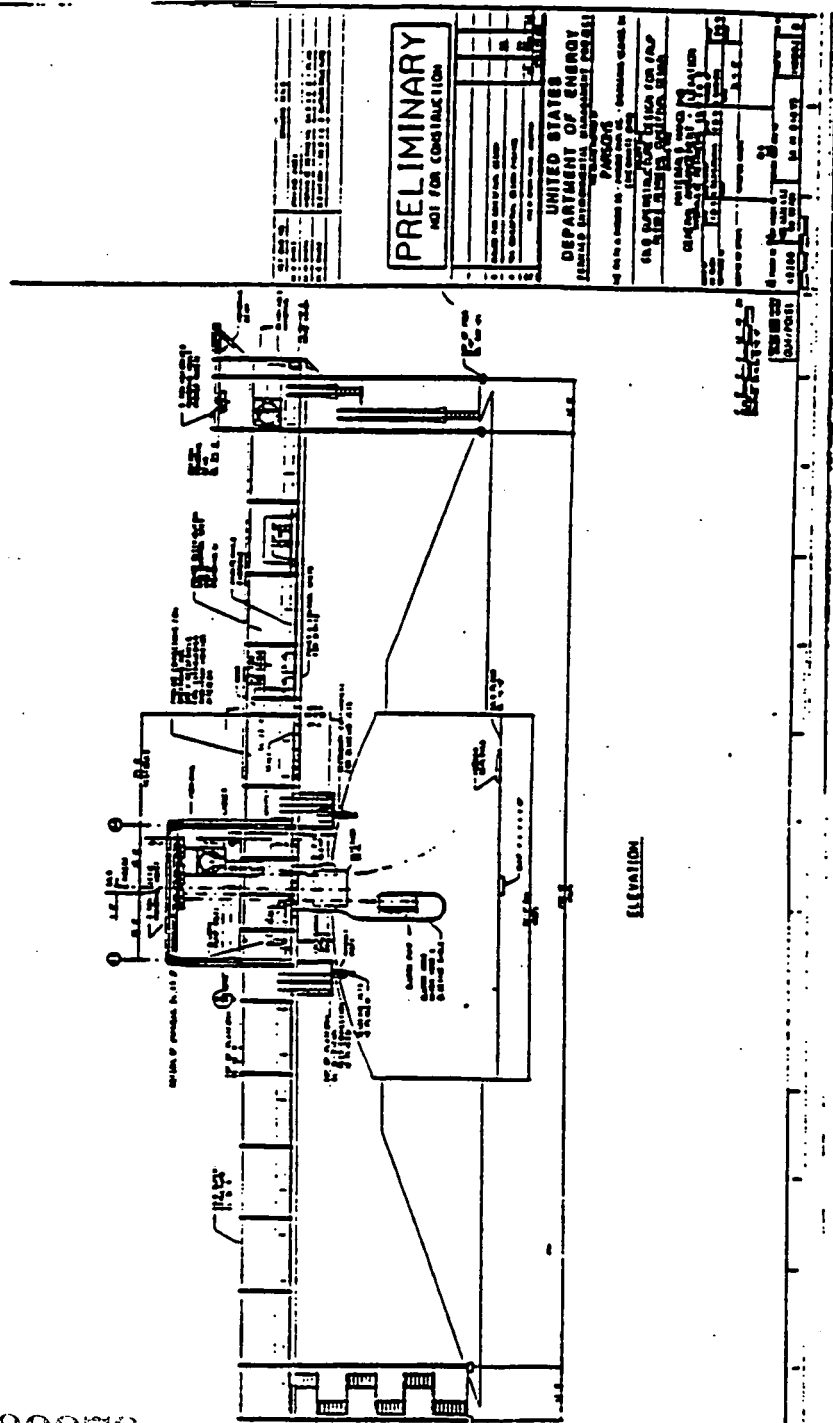
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SKETCH OF ORIGINAL DESIGN

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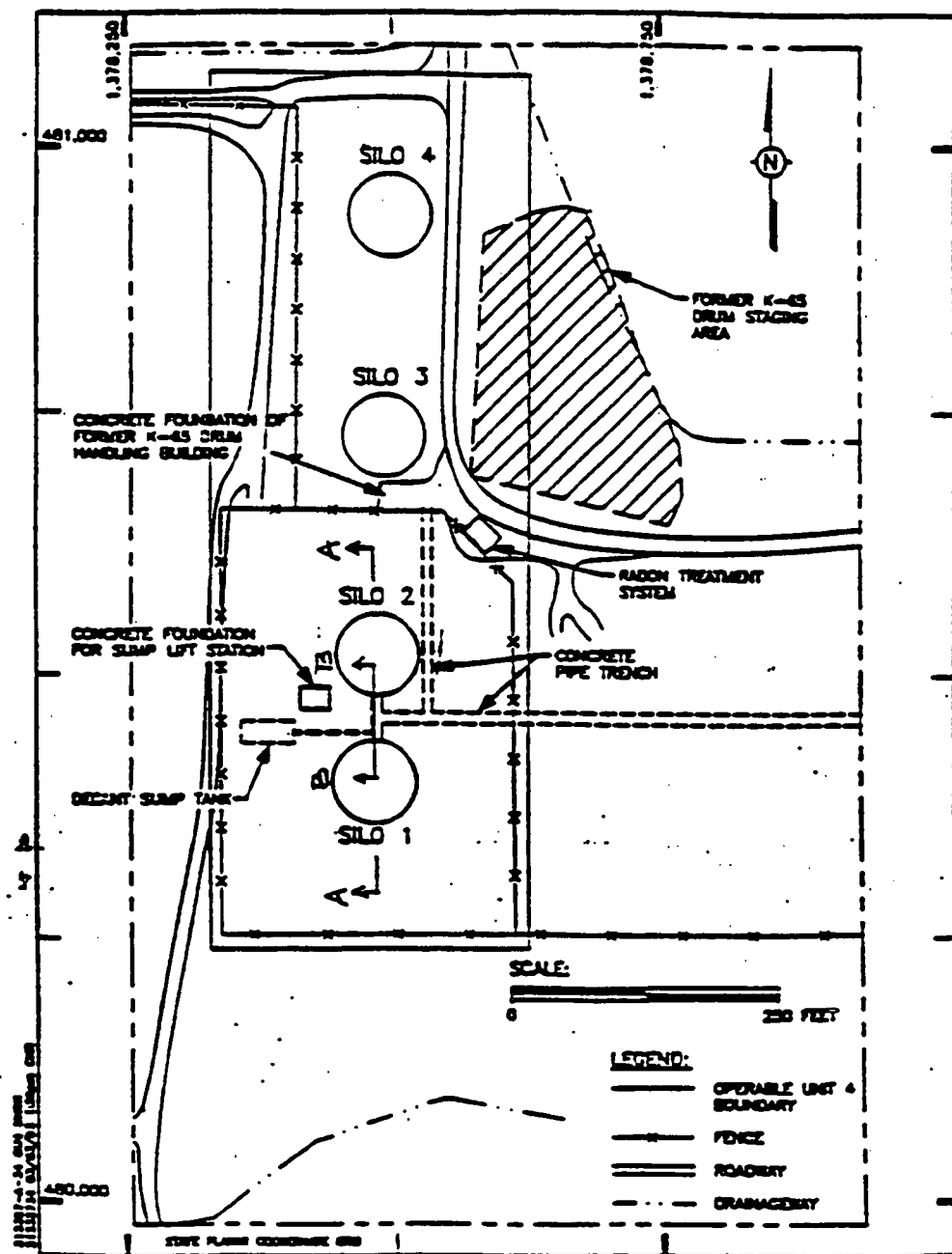
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SKETCH OF ORIGINAL DESIGN

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Sketch 2

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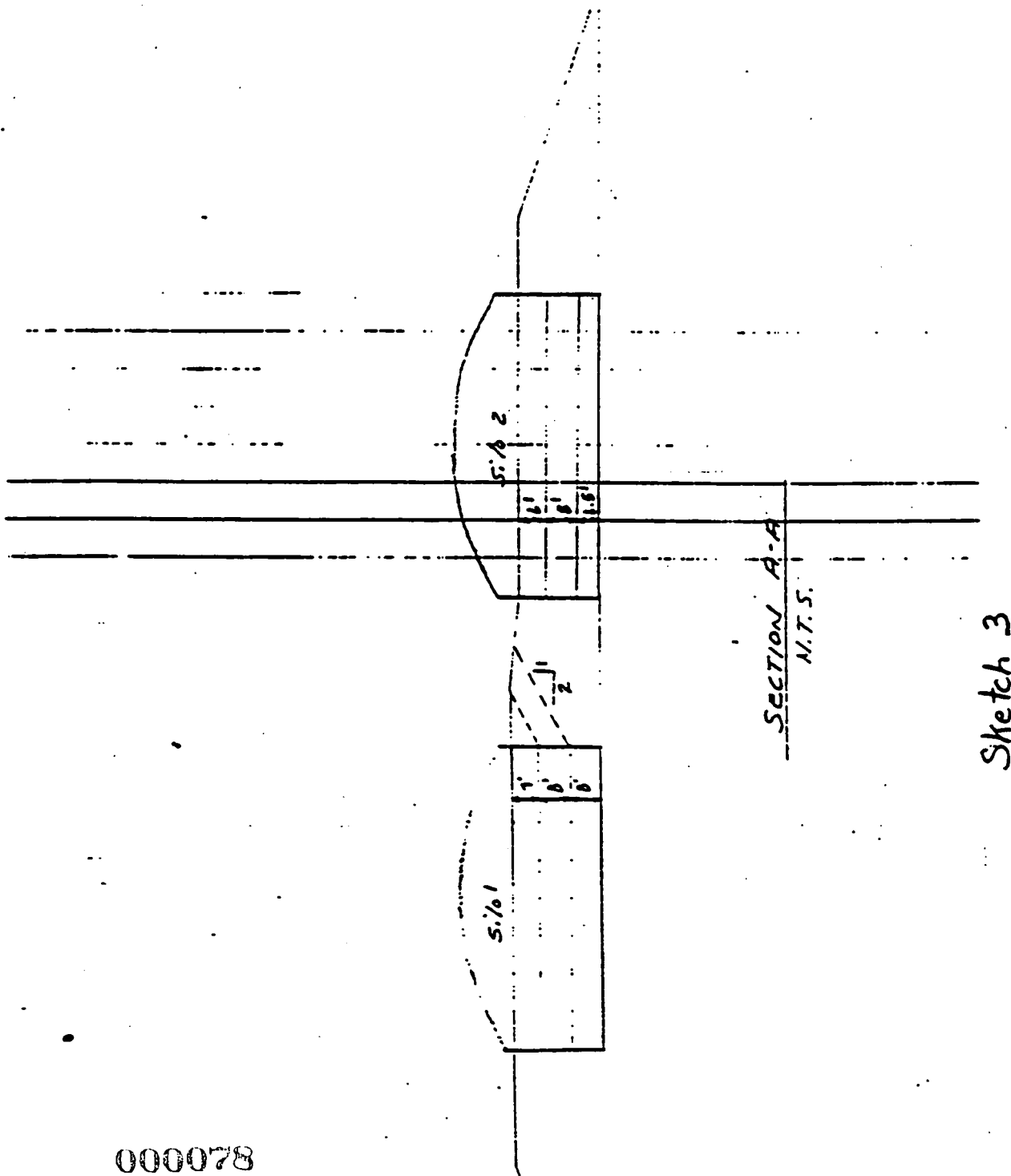
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 Fernald Environmental Management Project
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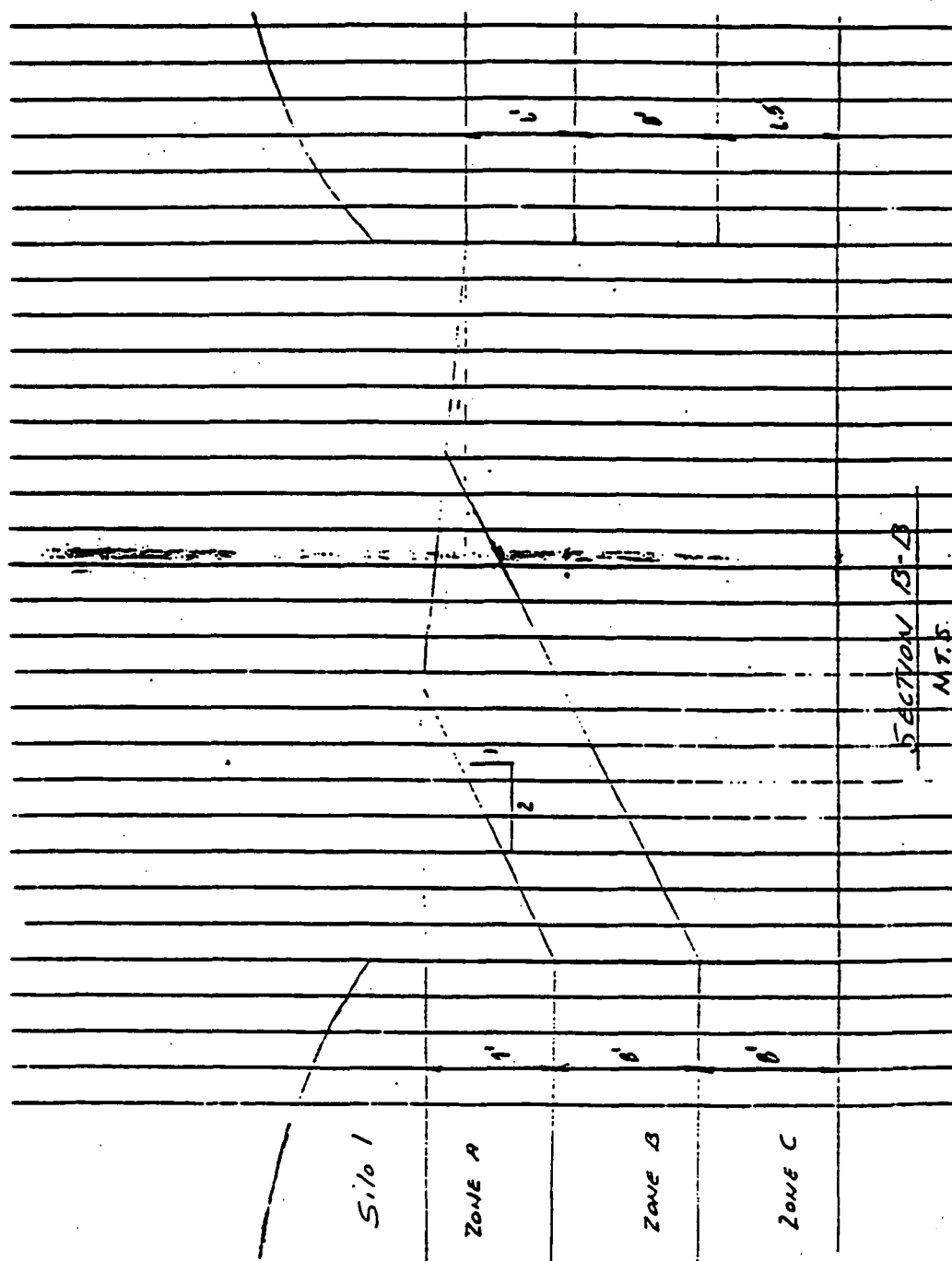
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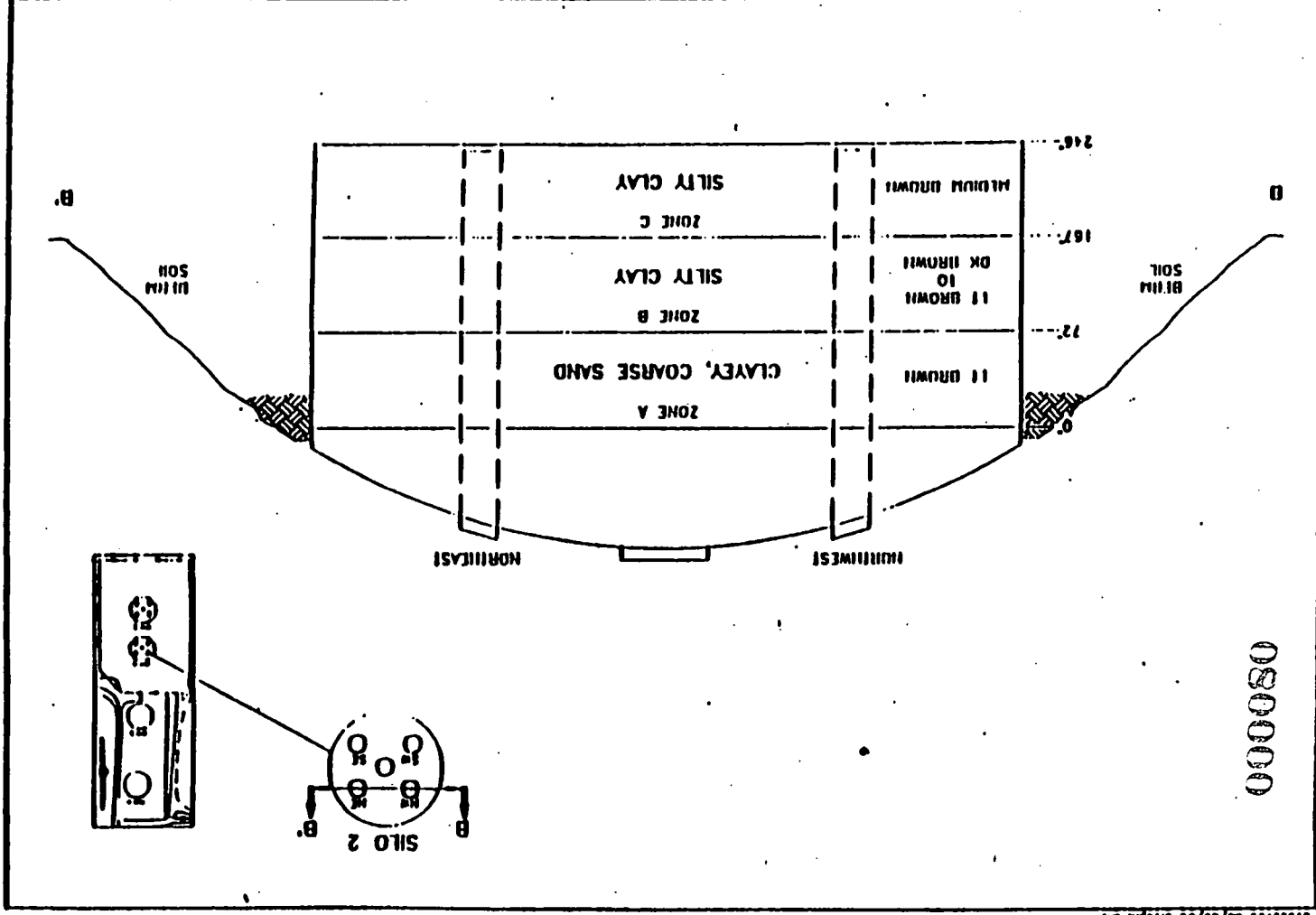


FIGURE 3-2. GENERALIZED VISUAL DESCRIPTION FOR SILO 2 CONTENTS

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OU4 Vitrification and Potential Alternatives

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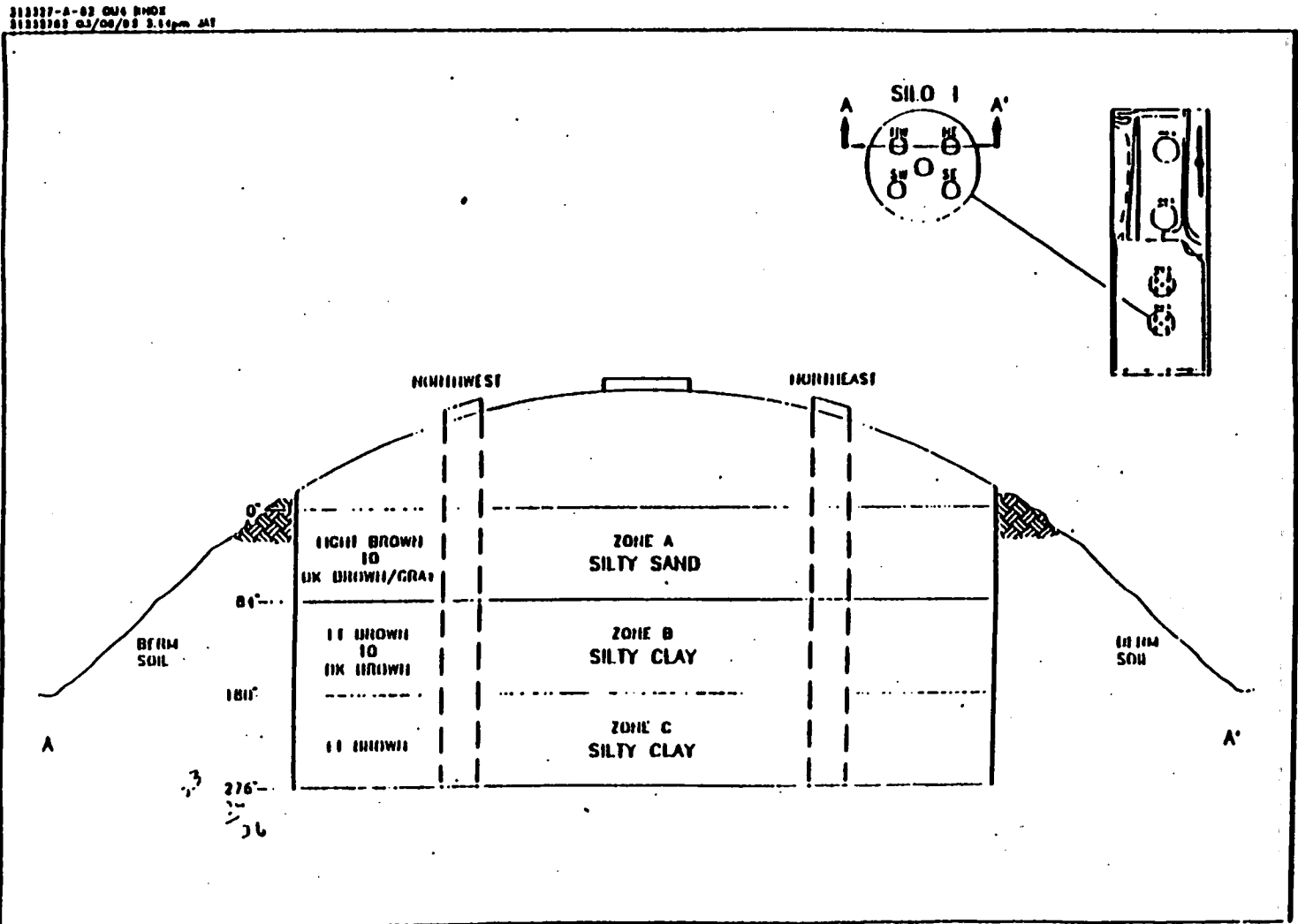


FIGURE 3-1. GENERALIZED VISUAL DESCRIPTION FOR SILO 1 CONTENTS

Sketch 6

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(1) Site Prep and Civil

Original Design - \$ 1,340,000 (Est. dated 12/24/96)

Both the original design and proposed design will require the same site preparation. Four foundations will be constructed. Preliminary site grading will reduce 1V:3H slopes to 1V:2H slopes for footing construction. Stair footings, walkways, parking + vehicle access are all still required.

Bottom line: Cost for Original Des = Proposed Des.

(2) Superstructure fabrication and delivery

Original Design \$ 2,800,000 (Est. dated 12/24/96)

Original design calls for 2 superstructures complete. By eliminating one superstructure, fabrication and delivery will be eliminated for one structure.

	Materials	Labor	6% Sales Tax	5.9% Risk Factor	Total
Original	1,334,500	1,230,500	80,100	154,900	2,800,000
Proposed	667,250	615,250	40,050	77,450	1,400,000

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(2) Superstructure fabrication and delivery

(Continued)

Add 5% for replacement of misc materials

$$5\% \times \$1,400,000 = 70,000$$

670 Sales Tax 4,200

\$74,200

Total Proposed 1,400,000; -

74,200

\$1,474,200

Feb + Delivery

VALUE ENGINEERING RECOMMENDATION

FORM 30 DEC 1966

CALCULATIONS

IDENTIFICATION NUMBER: A2.1

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(3) Assembly + Erection

Original Design = \$1,680,000 (Est. dated 12/29/76)

New design partially eliminated erection cost due to re-use of Silo 1 structure. Same disassembly of Silo 1 Superstructure, and re-assembly at Silo 2 will be required.

Assume - All equipment required, 1/2 materials
 1/4 labor and subcontractor for second structure (erection over Silo 2)

	Materials	Equip	Labor	6% Sales Tax	2.2% Risk	Total
Original	361,100	338,700	827,780	42,000	110,420	1,680,000
Proposed	180,550	338,700	620,836	31,155	84,329	1,255,570

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OU4 Vitrification and Potential Alternatives

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14) Miscellaneous Equipment

Original Design - \$2,106,171

Assume equipment is re-usable, with 10% replacement required

	EDC	Mat'l/Equip	Labor	Sales Tax	Risk 14.52	Total
Original	639,219	718,789	375,274	46,716	266,173	\$2,106,171
Proposed	319,609	428,334	187,637	25,693	139,384	\$1,100,657

(5) D&D Silo Superstructures

**LIFE CYCLE COST BASELINE (OUT YEARS)
SUMMARY PLANNING ACCOUNT ESTIMATE**

REVENUE AND OTHER DESCRIPTIONS	LABOR	CONTROL ACCOUNT MATERIAL	GRS	CURRENT PLANTING ACCOUNT TOTAL
Substructure/Construction			\$180,000	
	\$0	\$0	\$180,000	90,000 \$180,000
Project Management/Construction Management	\$28,000			
Health & Safety - Red Control				
	Proposed 14640			
	New \$28,000	\$0	\$0	14,000 \$28,000
Engineering	\$5,000			
	Proposed 5000			
	New \$5,000	\$0	\$0	5000 \$5,000
Other Management	\$7,000	\$3,000	\$12,000	
	\$7,000	\$3,000	\$12,000	6000 \$22,000
Risk Budget @ 11%				
	\$4,000	\$300	\$21,000	12,650 \$25,300
	\$44,000	\$3,300	\$213,000	137,650 \$260,300

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COST ESTIMATE - FIRST COST

IDENTIFICATION NUMBER: A2.1

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Cost Item	Units	Unit Cost		Original Design		Recommended Design	
		\$/Unit	Source Code	Num of Units	Total \$	Num of Units	Total \$
Site Prep/Foundation	LS	1,340,000	1	1	1,340,000	1	1,340,000
SS Fab & Delivery	LS	1,400,000	1	2	2,800,000	1	1,400,000
SS Erection	LS	840,000	1	2	1,680,000	1.3	1,092,000
Misc. Equipment	LS	1,053,085	1	2	2,106,171	1	1,100,657
Structure D & D	LS	130,150	1	2	260,300	1	130,150
Mob/Demob *	LS	0	7	0	0	1	100,000
Totals					8,186,471		5,162,800
* Mob & demob covered under SS erection. One SS requires one additional mob/demob							
Contingency (risk) and sales tax is included with line items							

SOURCE CODE: 1 Project Cost Estimate
 2 CES Data Base
 3 CACES Data Base

4 Means Estimating Manual
 5 Richardson's
 6 Vendor Lit or Quote (list name / details)

7 Professional Experience
 (List job if applicable)
 8 Other Sources (specify)

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Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

FORM 20 DEC 1996

PROJECT: Critical Analysis of OU4 Vitrification and Potential Alternatives

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LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997

IDENTIFICATION NUMBER: A2.2

FUNCTION OF COMPONENT BEING CHANGED: Retrieve Waste

DESCRIPTIVE TITLE OF RECOMMENDATION: Use tower crane instead of 2
 superstructures for waste retrieval.

ORIGINAL DESIGN:

One truss (superstructure) was to be built over each silo containing K-65 waste (i.e., silos 1 and 2). See backup sheet for design. These superstructures were to provide a platform from which to work and lower equipment (pump, Houdini, etc.) into the silo.

RECOMMENDED CHANGE:

Use a single tower crane to access both silos for waste retrieval. The crane can be used to install, support, and remove the Marconoflow pump and other equipment.

SUMMARY OF COST ANALYSIS			
	First Cost	O & M Costs (Present Worth)	Total LC Cost (Present Worth)
ORIGINAL DESIGN	9,474,105	0	9,474,105
RECOMMENDED DESIGN	2,767,158	0	2,767,158
ESTIMATED SAVINGS OR (COST)	6,706,947	0	6,706,947

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VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: A2.2

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ADVANTAGES:

- Cranes of some sort will be required anyway to set up superstructures.
- No design/engineering of a new structure; uses common construction equipment. Low cost. Much easier to get to site and set up.
- Crane may be able to be used for both silos (1 & 2) to allow removal of waste in layers. This will allow for berm removal on both silos and ensure silo stability.
- Quick setup time.
- Ideal for D & D work following waste retrieval.
- Lease instead of buy. If bought, definite market for salvage/reuse.
- Safer due to not being set up directly over silos during maintenance operations (i.e., less exposure to workers).
- Does not require a lot of site work to make area ready for assembly.
- Allows operation to be done from a safe distance.
- Minimal waste due to superstructure/foundation.

DISADVANTAGES:

- Requires operator to change position of tower crane (although, from safe distance).
- Although crane can quickly do/allow multiple tasks in series, it allows limited ability to do multiple tasks simultaneously (e.g., does not allow work to be done on both silos at the same time).
- Will require redesign of equipment room or the equipment room will not be included.
- Could result in crane activity becoming high consequence.
- Must provide another method of personnel access to the top of the silo.
- Will need to consider tower crane stability in high wind conditions.

JUSTIFICATION:

The waste retrieval method is currently a pump that is lowered into Silos 1 and 2 from their own superstructures. Instead of using two enormous superstructures that are being engineered, designed, and custom built for this sole purpose, a common tower crane can be used. These can be commonly found on construction sites of low and high rise buildings, etc. A single crane would provide access to any part of either silo dome. Tower cranes can be moved and erected comparatively quickly, require less space for erection, and are much cheaper. It is likely that an equipment room would not be used with the tower crane as is expected with the dedicated superstructures.

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Project EM - Phase 2 Report
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OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: A2.2

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JUSTIFICATION (continued):

However, work platforms can be used. If (or when) the pump needs to be removed from the silo(s), both would require gross contamination removal. After this, the superstructure would allow the pump to be pulled into the equipment maintenance area for routine maintenance, etc. Although this appears to be convenient and attractive, this work is in close proximity to a silo emitting radon gas and gamma radiation. A more appropriate solution is working on the ground away from the silos. A tower crane would allow quick wrapping of the pump and quick moving of the pump to the ground, vehicle, or containment. A tower crane would also allow quick, direct movement of the pump from one silo to the other. The tower crane would also be useful for many construction operations in the vicinity. It would be ideal for D & D operations of the tanks.

A report by Parsons Engineering dated March 1995 (Analysis of Silos 1 and 2 Superstructure Design Options PO-137 Residue Removal and Treatment Facility Title 1 Design) provides an approach for analyzing alternatives for waste removal. Unfortunately, only three alternatives were analyzed; each involved the use of fixed superstructures. However, if the use of a tower crane is used as an alternative and compared using Parson's six criteria, the VE team believes the tower crane is the most appropriate choice. The six criteria include cost, safety, changeover time, operational flexibility, usefulness in D & D, and volume of generated waste. These criteria are listed in decreasing order of importance. Compared to the three superstructure scenarios the tower crane: costs the least, was safest (did not require set up immediately over the silo, and did not encourage workers to stay over the hole in the dome for maintenance activities), provided the quickest changeover time, was even or better in operation flexibility, far more useful (in fact, ideal) in D&D, and produced the least amount of generated waste (only one foundation and much less structural steel).

It is important to realize that this is not the first time cranes have been used for this type of procedure. In fact, a crane appears to have been used in the operation to pump in the bentonite slurry into Silos 1 and 2.

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Fernald Environmental Management Project
OU4 Vittrification and Potential Alternatives

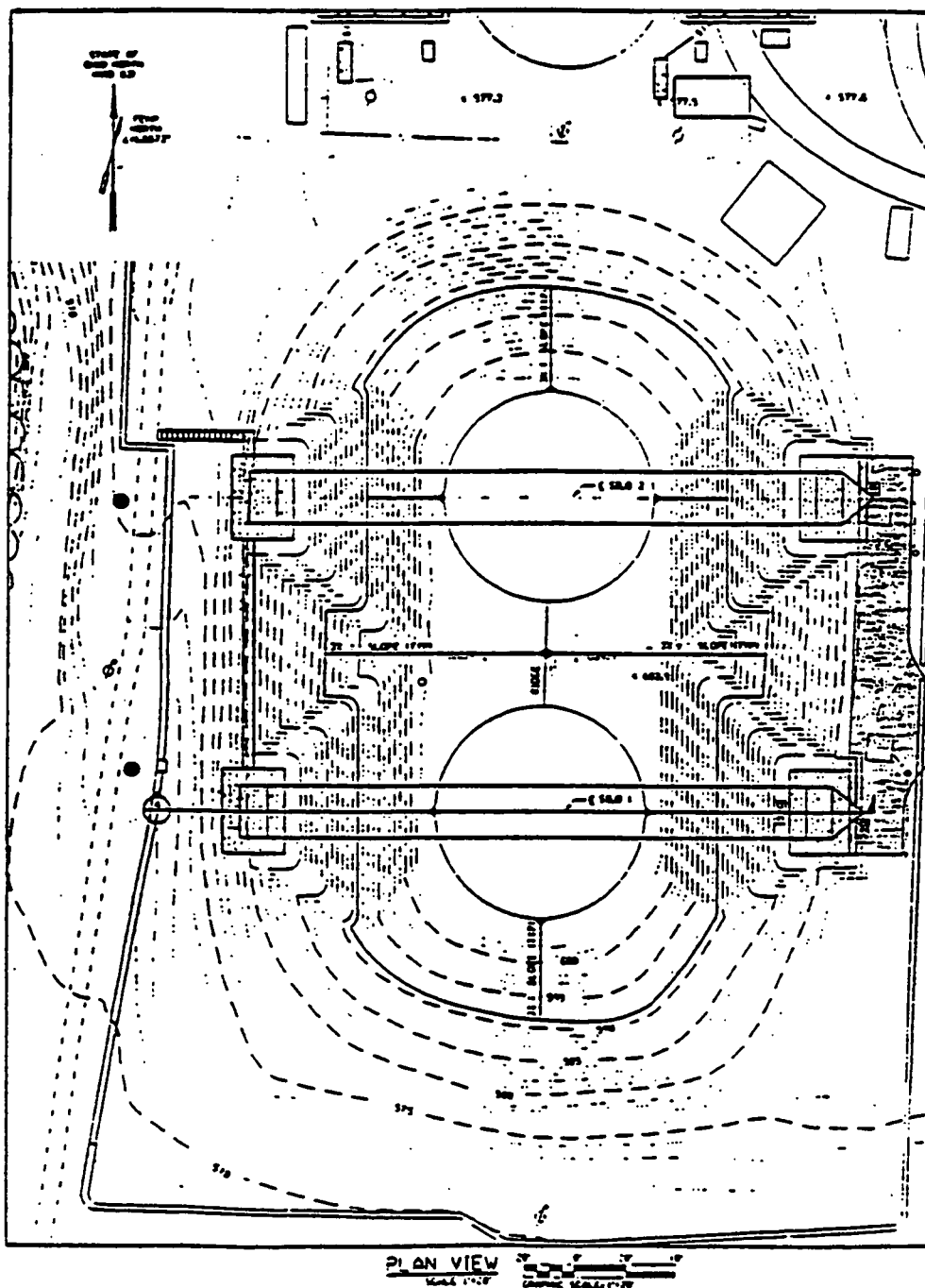
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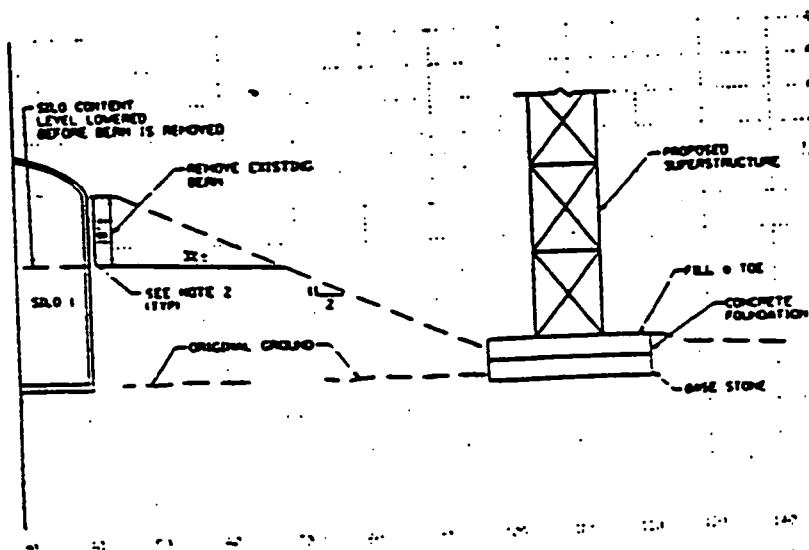
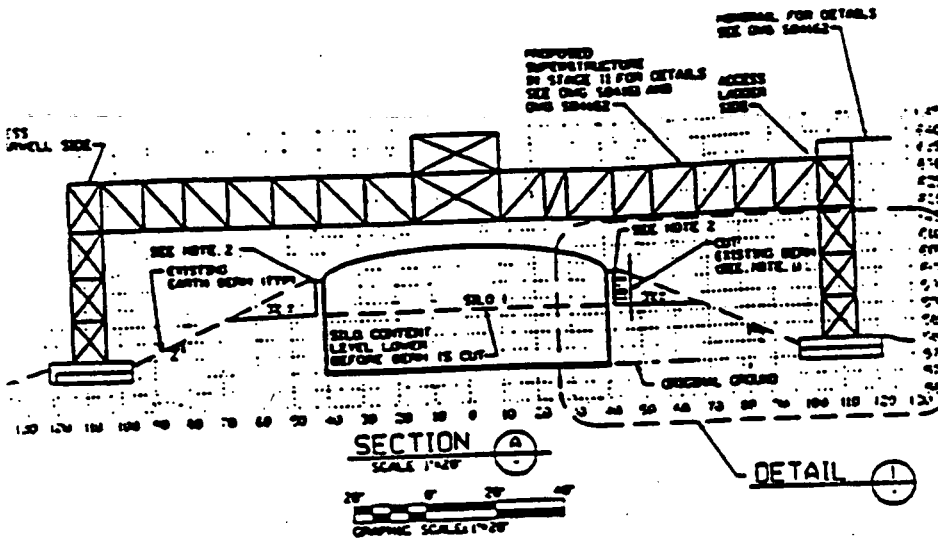
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Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives



- NOTES**
1. COVER DISTURBED AREAS WITH HYDROSEED AND HEAVY DUTY PROGRAMMABLE EROSION CONTROL MATING ANCHORED WITH STAPLES.
 2. REMOVAL METHODS FOR EXISTING SOIL MATERIALS WITHIN 7' OF THE SILO WALLS WILL BE DETERMINED AS A PART OF A LATER REVIEW.
 3. 1" - 45 DEGREE SLIP TIE ACCESS PIPE TO BE LOWERED WITH BEAM TO MAINTAIN ACCESS.

SYMBOLS LEGEND

EXISTING OR PREVIOUS PHASE	PROPOSED
	POWER POLE
	LIGHT POLE
	WINDMILL
	MONITORING WELL
	GRAVEL WALK ROADWAY/CONVEYOR
	PAVED ROADWAY/CONVEYOR
	CONCRETE PAD/FOUNDATIONS
	STEPS
	BUILDING/TRAILER
	FENCE
	TREE LINE
	SPOT ELEVATION
	CONTOUR - MINOR
	CONTOUR - MAJOR
	SLOPE

REF. DWG. NO.	DRAWING TITLE
SK-S-04163	DRAWING INDEX
SK-S-04164	PLANS - SILO 1 AND 2 SUPERSTRUCTURE
SK-S-04162	ELEVATIONS - SILO 1 AND 2 SUPERSTRUCTURE

PRELIMINARY
 NOT FOR CONSTRUCTION

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

THIS DRAWING PREPARED BY
PARSONS
 THE RALPH M. PARSONS CO. - PARSONS PARK, INC. - ENGINEERING-SCIENCE, INC.
 CINCINNATI, OHIO

PROJECT NAME
SILO SUPERSTRUCTURE DESIGN FOR FRVP RESIDUE RETRIEVAL CONCEPTUAL DESIGN

DRAWING NO.
CIVIL
STAGE II - BERM GRADING PLAN

DATE	BY	CHK'D	APP'D	DATE
11/14/97	J. P. HARRIS	J. P. HARRIS	J. P. HARRIS	11/14/97

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Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

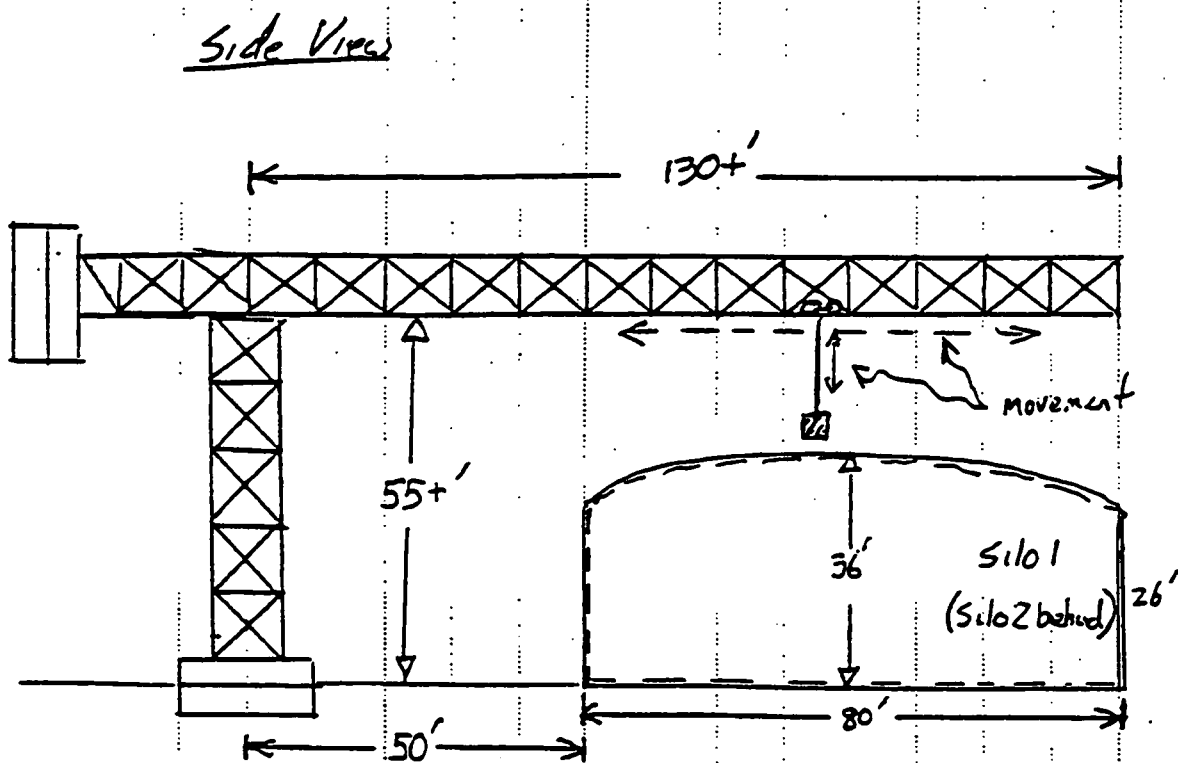
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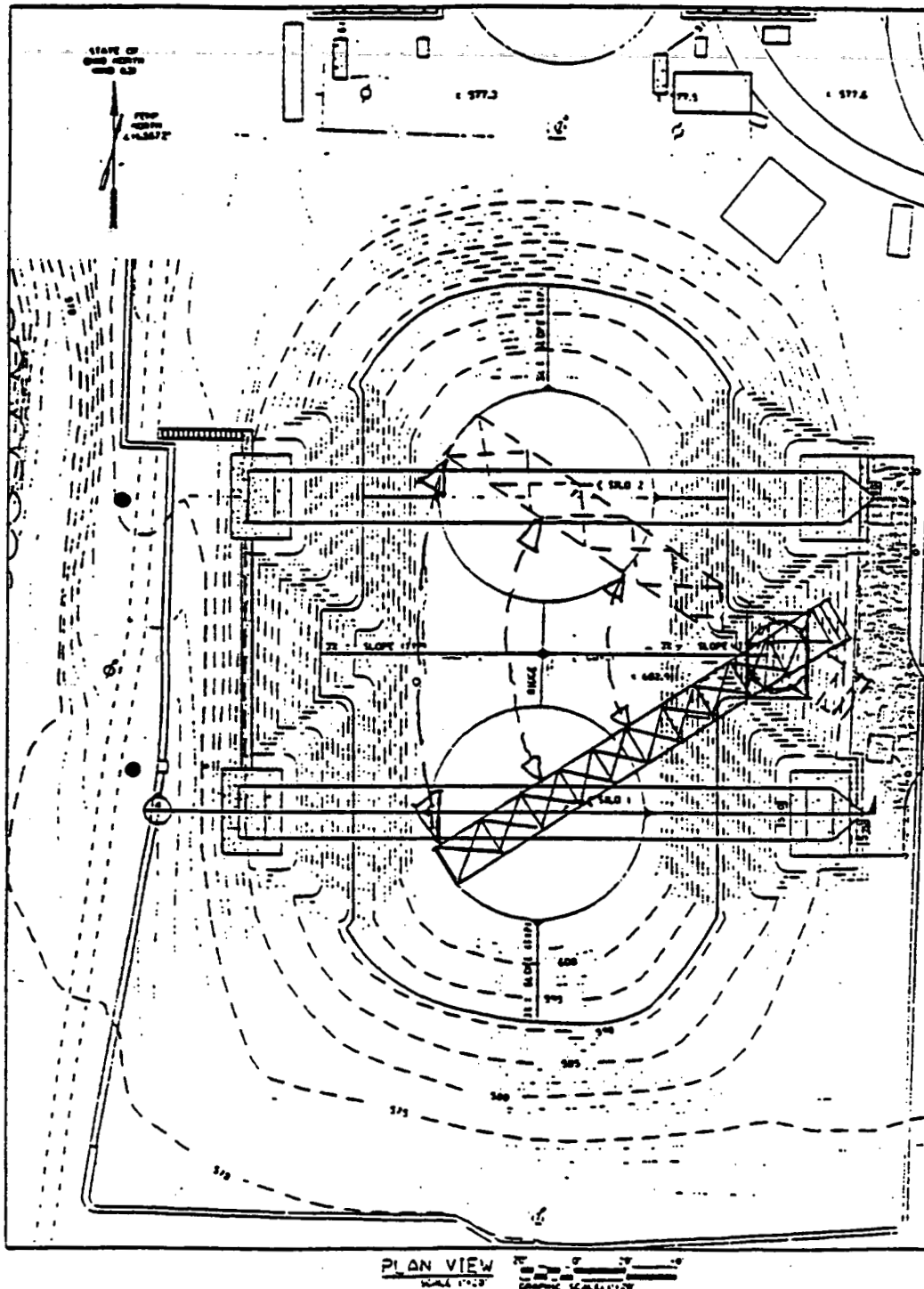
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SKETCH OF ORIGINAL DESIGN

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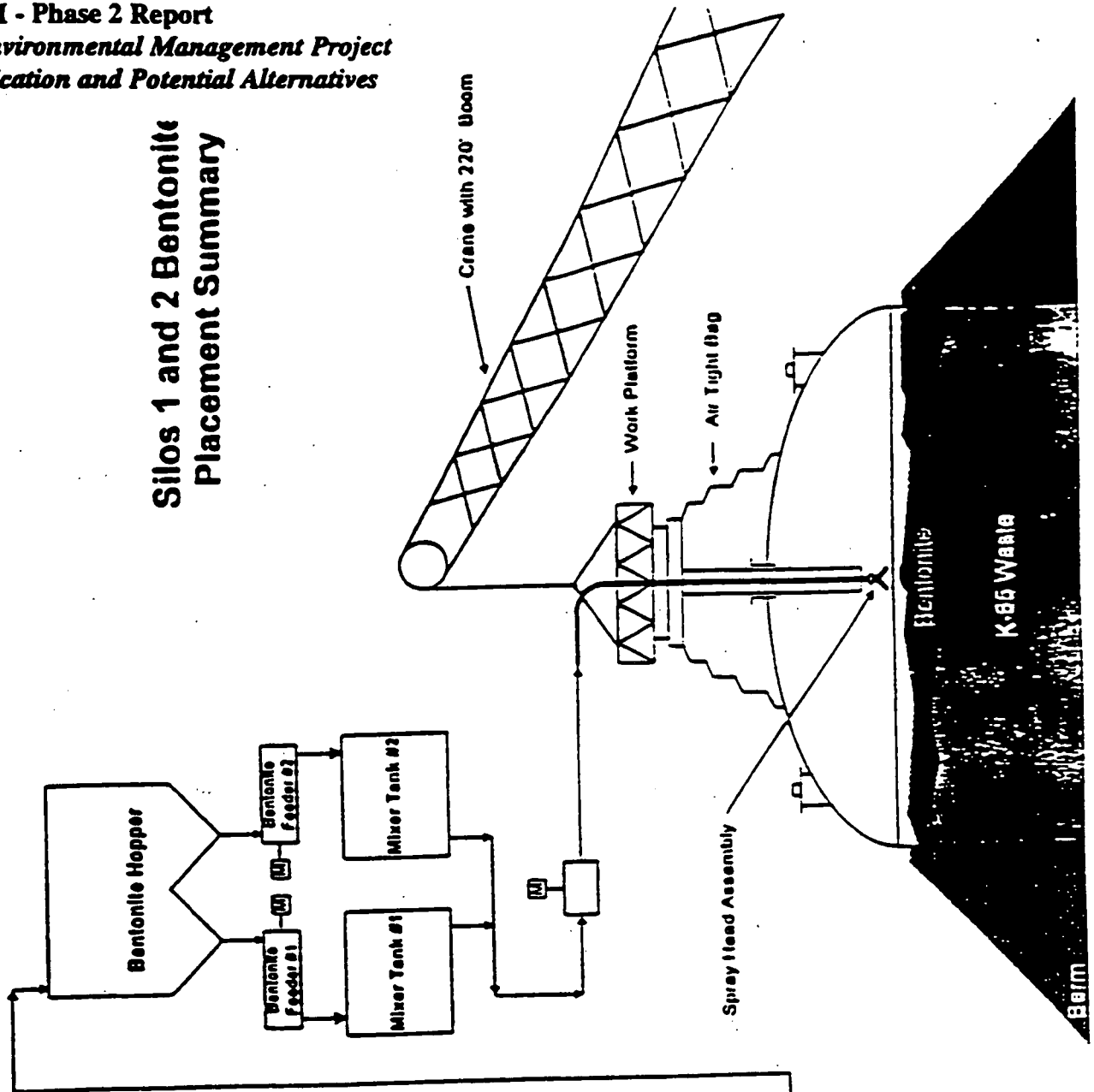
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 Fernald Environmental Management Project
 OU4 Vitrification and Potential Alternatives

Silos 1 and 2 Bentonite
 Placement Summary



*Note that a crane
 (mobile in this case)
 has already been used
 to put the bentonite
 slurry into the silos.*

*Bentonite Supply Truck with
 Pneumatic Unloading*

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FORM 20 DEC 1964

CALCULATIONS

IDENTIFICATION NUMBER: A2.2

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Crane Height - see page

Crane Radius - see pages

Crane Capacity - Calculate for dome section removal.

diameter = 6'

$$\text{area} = \pi r^2 = \pi \left(\frac{6}{2}\right)^2 = \pi \left(\frac{6}{2}\right)^2 = \pi 3^2 = 9\pi = 28.27 \text{ ft}^2$$

$$\text{volume} = \text{Area} \times \text{thickness} = 28.27 \text{ ft}^2 \times 0.5 \text{ ft} = 14.14 \text{ ft}^3$$

density of concrete = 150 lb/ft³

$$\text{weight of removed section of dome} = \text{vol} = (14.14 \text{ ft}^3)(150 \text{ lb/ft}^3)$$

$$= 2121 \text{ lb}$$

$$= 2121 \text{ lb} / (2000 \text{ lb/ton})$$

$$= 1.06 \text{ tons}$$

Weight of manure flow pump = 2800 lb

$$= 1.4 \text{ tons}$$

Increase for possible: work platform, airtight bag, equipment room,
 etc.

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Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

TOWER CRANE (A2)

WASTE RETRIEVAL

Sitework and Civil	1 M
Radon Treatment System	2 M
Waste Retrieval System (1&	2 M
Assembly and Erection	2 M
Fabricate and Deliver	2 M
Waste Retrieval Equipment (3 M
Demonstration Projects????	1 M
Subtotal	13 M

Risk Budget	3 M
Total	16 M

Sitework and Civil	1 M
Assembly and Erection	2 M
Fabricate and Deliver	3 M
Subtotal	6 M

Sitework and Civil

General Site Work	102,500
Machine Excavation and Backfi	111,900
Concrete Work	101,400
Structural Steel Work	1,300
Piping Work	3,250
	320,350

Support Cont. Field Cost	320,350
SC Indirect Field Cost	107,472
Support Cont. Total Bill Co	427,822

FDF Ind. Field Cost	224,995
FDF Direct Field Costs Total	200,899
FDF Dir. & Indir. Field Cost	425,894

FDF Sales Tax	25,198
---------------	--------

Subtotal	878,914
Risk (@4.6%)	40,430

Total	919,344
--------------	----------------

Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

TOWER CRANE (A2)

Silo SS - Fab. and Transport

	Material	S/C	Total
Crane	517,100		
Crane Delivery		\$8,800	
Direct Field Costs Total	517,100	\$8,800	
Sales Tax	33,612	\$0	
Subtotal	550,712	\$8,800	559,512
Risk Budget			33,011
Total			592,523

Silo S.S. - Assembly and Erection

	Material	S/C	Total
Unload	4,400		4,499
Erection		\$50,000	50,000
Direct Field Costs Total	4,400	\$50,000	54,400
Indirect Field Costs Total			65,942
Direct and Indirect Field Cost			120,342
Sales Tax			330
Subtotal			120,672
Risk Budget (7.2%)			8,688
Total			129,360

Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

TOWER CRANE (A2)

COMPARISON OF COSTS

	Current	Suggested
Sitework and Civil	\$ 1,340,000	\$ 919,344
Fabricate and Deliver	\$ 1,680,000	\$ 592,523
Assembly and Erection	\$ 2,800,000	\$ 129,360
Subtotal	\$ 5,820,000	\$ 1,641,227
Contingency (30%)	\$ 1,746,000	\$ 492,368
Subtotal	\$ 7,566,000	\$ 2,133,595
Silo Superstructure D&D	\$ 1,908,105	\$ 633,563
Total	\$ 9,474,105	\$ 2,767,158
Savings	\$ 6,706,947	

Project EM - Phase 2 Report
 Fernald Environmental Management Project
 OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

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CALCULATIONS

IDENTIFICATION NUMBER: A2.2

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D&D COSTS OF THE RECOMMENDED DESIGN

ASSUME: (1) 1/4 of structural steel in overhead crane than
 in two superstructures

(2) 1/2 of concrete in foundation, etc. in O/H crane than SS

$$\text{STEEL} - 22.9 \text{ MH/T} \times 1.5 = 34.35 \text{ MH/TON} \times 0.25 (665 \text{ tons}) \times \$21.04/\text{hr} = \$120,153$$

$$\text{CONCRETE} - 17 \text{ MH/CY} \times 1.5 \times \$18.56/\text{HR} \times 0.5 (400 \text{ CY}) = \$117,373$$

$$\text{Direct Cost} = \Sigma (\text{steel} + \text{concrete}) = \$237,526$$

$$\text{S/C} = (81.53\%) \text{ DC} = \$193,655$$

$$\text{PRJ/CM} = (15.8\%) \text{ S/C} = 30,597$$

$$\text{ENGR} = (3\%) \text{ S/C} = 5,810$$

$$\text{WM} = (12.1\%) \text{ DC} = 28,741$$

$$\text{SUBTOTAL} = \$496,329$$

$$\text{TOTAL (INCLUDING RISK BUDGET)} = \$550,925$$

NOW ADD ADDITIONAL CONTINGENCY (SEE OTHER SHEET
 TITLED "D&D/WASTE PACKAGING"
 UNDER "BASIS OF ESTIMATE,"
 ALTERNATIVE #2")

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Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

BASIS OF ESTIMATE
ALTERNATIVE #2

D&D / WASTE PACKAGING

D&D & Waste management costs were revised to reflect the uncertainty of the soils disposition of the silo berm and immediately beneath the silos. This increased waste disposal is attributed to the soil requiring disposal at NTS (discussed below), and the reopening of the OSDF as a result of delinking the Silos Projects from the Site Master integrated schedule.

The basic assumption used in this alternative is that approximately 20% of the OU4 soils will have to be treated via vitrification. The volume of soils is a rough order of magnitude (ROM) estimate of 20% of the total volume of OU4 area soils anticipated to be removed.

D&D estimates were based on the FY96 baseline estimate and a factor for increased Final remediation facility requirements to go from one 25 ton/day melter to three melter trains.

A 15% risk has been applied to the D&D and Waste management estimates, therefore the expected value \$143 million.

+(Additional 15% Risk)

~~1,334,290~~
~~200,144~~
~~\$1,534,434~~

ORIGINAL
1,659,222
+ 248,883
1,908,105

SUGGESTED
\$550, 925
+ 82, 639
\$633,563

SAVINGS =
= ORIGINAL - SUGGESTED
= 1,908,105
623,563
\$1,274,541

000100

Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives



PARSONS

8120 South Gilmore Road
 Fairfield Executive Center
 Fairfield, OH 45014
 (513) 870-0300
 Fax (513) 870-0444

March 24, 1995
 PARSONS ID#:04:137:223:0034-95

Mr. Roger Emerton
 Fernald Environmental Restoration
 Management Corporation
 P.O. Box 538704
 Cincinnati, OH 45253-8704

Subject: Analysis of Design Options for Silo 1 and 2 Superstructures
 Project Order 137 (PO-137)
 Residue Removal/Treatment design, CRU-4
 Subcontract No. 2-21487
PARSONS Environmental Remedial Action Project

Dear Mr. Emerton:

In order to develop a design approach for the Silo 1 and 2 Superstructures, PARSONS has conducted the subject analysis and has attached it for your review. Some of the criteria used in this study can only be fully evaluated after the completion of Pilot Plant operations. This study, however, provides a reasonable justification for the design approach selected.

If you have any questions, please contact me at 870-8275, or Paul Frink at 870-8339.

Very truly yours,
 PARSONS

for

[Signature]
 Anthony P. Pyrz
 Project Manager, CRU-4

APP:nw
 Attachment
FERMCO * w/o attachment

B.K. Copsey (MS 5)*
 N.E. Hopson (MS 81-3)*
 M.C. Skriba (MS 82-2)
 Doyal C. Wright (MS 81)*
 M. Dehring (MS 82-2)*
 D. A. Nixon (MS 82-2)
 S. H. Wolinsky (MS 82-2)*

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Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vittrification and Potential Alternatives

Table 2 - Summary of changeover times (see note 1)

Activity	Alternative A	Alternative B	Alternative C
Pull hydraulic pump from structure	1-2 days	1-2 days	see note
Use robot to remove remaining waste	- 1 month	- 1 month	see note
Seal silo opening and remove equipment	1 week	1 week	see note
Move Superstructure to other silo	2 weeks	1-2 days	see note
Set-up, cut dome, insert transition, hydraulic pump, test and begin extraction	1 month	1 month	see note
Change operational valve line-up	included in the above	included in the above	- 1 day
Total changeover time	- 3 months	- 10 weeks	- 1 day

Note: These activities conducted during extraction activities on the first silo

- a) 2 Alternative A has the longest changeover time due to the complexity of the superstructure disassembly/reassembly. Additionally, after the superstructure has been moved, set-up, testing, and dome cutting operations must precede recommencement of extraction. Total changeover time is expected to take up to 3 months.
- b) 2 Alternative B reduces the changeover time by 1 to 2 weeks, but set-up, testing, and dome cutting operations still must occur before extraction can resume. Total changeover time is expected to take approximately 10 weeks which is not significantly shorter than Alternative A.
- c) 5 Alternative C has a substantially shorter changeover time because set-up, testing, and dome cutting operations can occur on the second silo while extraction is in progress on the first silo. Changeover time in this case would be nearly instantaneous (several hours); this would allow the furnaces to continue operation at full capacity.

ENCLOSURE TRANSMISSIONS

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Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

Summary

The score assigned to alternatives for each criterion are weighted according to their importance to the overall project. The criteria of cost and safety are given a triple weighting as they are primary considerations in the design of the structures. Changeover time and risk of delay are weighted double as they are secondary considerations. The two remaining criteria, usefulness in D&D, and volume of waste generated, are tertiary considerations and therefore receive no weighting. Table 2 provides a summary of the weighted grades assigned for each alternative, along with a total score for that alternative. These results indicate that the preferred alternative is C. Alternative C provides two independent superstructures for Silos 1 and 2. Each structure remains in place throughout the duration of extraction operations and final clean out, as well as decontamination and dismantling, if necessary.

Alternative A received the second highest score. This alternative provides for a single superstructure which is relocated after the first silo is emptied. The greatest advantage of this alternative is the cost savings achieved through the re-use of the single superstructure. It is unsure though to what extent operational costs might offset these savings. The other criterion where Alternative A scores higher than Alternative C is in the smaller volume of waste generated.

Alternative B has several strong points in safety and usefulness in D&D, but the higher cost combined with an extended changeover time and risk of delay make it the least preferred alternative.

Table 2 - Grading of Alternatives by Criteria

Criteria	Weighting	Alternative A	Alternative B	Alternative C	Tower Crane
Cost	3	$4 \times 3 = 12$	$2 \times 3 = 6$	$2 \times 3 = 6$	$5 \times 3 = 15$
Safety	3	$3 \times 3 = 9$	$3 \times 3 = 9$	$3 \times 3 = 9$	$3 \times 3 = 9$
Changeover Time	2	$2 \times 2 = 4$	$2 \times 2 = 4$	$3 \times 2 = 6$	$4 \times 2 = 8$
Operational Flexibility	2	$2 \times 2 = 4$	$2 \times 2 = 4$	$3 \times 2 = 6$	$4 \times 2 = 8$
Usefulness in D&D		3	3	4	$5+ = 5+$
Volume of Generated Waste		3	2	3	$5+ = 5+$
Total Weighted Score		37	36	42	50+

The use of a single, non-mobile crane got a low score compared to the other two based on two criteria: "Change Over Time" and "Ops Flexibility." If one is assured that cementation is to be used, then downtime is less critical. If one assumed the slope could be reduced with inexpensive shoring methods, then the Op Flex would be less critical.

ENCLOSURE TRANSMISSIONS-IT

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Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vittrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

FORM 20 DEC 1996

PROJECT: Critical Analysis of OU4 Vittrification and Potential Alternatives

Page 1 of 15

LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997

IDENTIFICATION NUMBER: C1.1

FUNCTION OF COMPONENT BEING CHANGED: Treat Contents

DESCRIPTIVE TITLE OF RECOMMENDATION: Treatment Consideration of Silos 1, 2, and 3.

ORIGINAL DESIGN:

Remove sludge for Silos 1 and 2 and treat by vittrification. Remove metal oxides from Silo 3 and treat by cementation. (Alternative 2 presented to the IRT.)

RECOMMENDED CHANGE:

Remove contents from all three silos and treat with the appropriate solidification/stabilization process. (Alternative 3 presented to the IRT.)

SUMMARY OF COST ANALYSIS			
	First Cost	O & M Costs (Present Worth)	Total LC Cost (Present Worth)
ORIGINAL DESIGN	\$604,000,000	0	\$604,000,000
RECOMMENDED DESIGN	\$588,000,000	0	\$588,000,000
ESTIMATED SAVINGS OR (COST)	\$46,000,000	0	\$46,000,000

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Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: C1.1

Page 2 of 15

ADVANTAGES:

- Allows completion of Ohio Ten Year Plan by 2005 as originally scheduled.
- Will produce substantial cost savings do to reduced disposal volume.
- Chemical fixation and solidification at ambient temperatures is inherently safer than vitrification at highly elevated temperatures.
- The proposed process meets all regulatory requirements at minimum expense.

DISADVANTAGES:

- Will require modifying the existing Record of Decision (ROD).
- Produces a waste form which is less durable than glass.
- Not supported by the VE team because the waste loadings are based on surrogate materials which are not necessarily representative of the silo waste.
- If cost estimates are based on these extreme waste loadings, substantial cost impact will occur if disposal criteria cannot be met.

JUSTIFICATION:

Within DOE and worldwide, there are no known examples of successful large scale use of exsitu vitrification of low level mixed waste. Vitrification has become the preferred method for treating high level waste because of the durability of the final waste form. However, the cost of producing the durable glass waste form using vitrification for low level waste has not been cost competitive with other treatment methods.

The vast majority of the low level mixed waste within DOE and the commercial world is treated by some form of chemical fixation and solidification before burial in an approved cell. This was

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VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: C1.1

Page 3 of 15

JUSTIFICATION (continued):

certainly true at both Savannah River and West Valley where the low level waste was cemented and the high level waste is being vitrified.

It is now known that in order to remove the materials from the three silos at Fernald (OU4), and dispose of them off-site, the materials need only be treated sufficiently to pass the Toxic Characteristic Leaching Procedure (TCLP), and shipped to a disposal site [e.g., Nevada Test Site (NTS)] in a strong, tight container while meeting Department of Transportation (DOT) shipping regulations. At the time of Remedial Investigation/Feasibility Study (RI/FS), where vitrification was chosen as the preferred alternative, it was believed that the only off-site burial option available was one which required the treated waste to meet the Nuclear Regulatory Commission (NRC) requirements.

In order to bury low level waste at an NCR site, it was believed that the final waste form must have a minimum unconfined compressive strength (UCS) of 500 pounds per square inch (psi). The two preferred alternatives selected in the FS were cementation and vitrification which both met the NRC requirements for off-site burial. However, in order to achieve the 500 psi requirement, the cementation process could only achieve a waste loading of approximately 30% which increased the volume of waste for shipment and burial to more than triple the original volume in the silos. Because of the excessive volume increase, the cost of vitrification was estimated to be significantly less than the cost of cementation on a life cycle basis. In addition, vitrified glass retained radon better than the more porous cement. Primarily for these reasons, the vitrification process was selected as the preferred alternative in the ROD.

As has been the case with all DOE vitrification projects, the original cost and schedule baseline estimates for the OU4 presented in the FS were very optimistic (see attached Tables 5-6 and 5-8 from the FS Report). The original present worth cost to vitrify Silos 1 and 2 waste was estimated to be \$43.7M and for Silo 3 waste, \$28M. These costs were considered order of magnitude estimates with an intended accuracy range of -30% to +50%. The order of magnitude estimate (-30% to +50%) presented to the IRT was \$541M to vitrify Silos 1 and 2.

In the FS Report, the order of magnitude cost for cementation of Silos 1 and 2 waste was \$73M and for Silo 3 waste, \$35.9M. The estimate presented to the IRT for cementation of all three silos waste is \$479 (-30% to +50%). However, the current estimate for cementation of Silo 3 is \$25M, which is believed to be based on an unsolicited proposal from a reputable vendor to remove, treat, and bury the Silo 3 waste for approximately \$15M. The remaining \$464M for cementation of Silos 1 and 2 in the IRT estimate was calculated from the FS treatability data. The

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Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: C1.1

Page 4 of 15

JUSTIFICATION (continued):

recipe selected produced a 500 psi final waste form, used a 20% waste loading, and resulted in a 340% increase in the original volume of Silos 1 and 2 waste.

The cost of sacrificing waste loading to achieve compressive strength is well documented in DOE. At West Valley, the low level waste cementation was originally formulated to achieve 50 psi compressive strength with an approximate 40% waste loading. The NRC changed the compressive strength requirement to 500 psi and the waste loading decreased to approximately 20%. At Weldon Springs, pit material (raffinate) of composition similar to Silos 1 and 2 waste is being grouted and buried in an on-site cell. In addition to passing the TCLP, the grout must have a 50 psi compressive strength. Their pilot plant work showed that a 60% waste loading could not consistently produce the required 50 psi, and they have chosen to use approximately 45% waste/cement as a conservative approach to assure obtaining the necessary compressive strength.

Recently, samples of Silo 3 waste were sent to Nuclear Fuel Services (NFS) for stabilization testing. The data reported from NFS are presented in an attached table and show that at 40% waste / 60% cement, the Silo 3 material achieves 500 psi. At 70% waste/30% cement, the Silo 3 material achieves 85 psi. When Aquaset II is used instead of cement, a strength of 15 psi is achieved with an 80% waste/20% cement loading (Aquaset is a mixture of specialty clays). If there is no strength requirement, then 90% waste/10% cement or more of waste loading is not only conceivable, but has actually been done at Fernald with mixed waste.

Between May, 1995 and September, 1996, some 2300 containers of legacy mixed waste were successfully treated at FEMP using a fixed price subcontract. Of particular interest to this study were 545 drums of uranium oxide which contained arsenic, barium, chromium, lead, selenium, and silver (black oxide). Approximately 40 pounds of Portland cement and 500 grams of sodium sulfite were added to approximately 700 pounds of the black oxide and about 30% water was added to the mixture. The resulting thick slurry was poured into white metal boxes and shipped to NTS for burial. The treated material passed TCLP and was not tested for strength since there was no requirement. As can be seen, on a dry weight basis, this formulation is over 94% waste loading with little, if any, volume increase.

000107

VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: C1.1

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JUSTIFICATION (continued):

In the draft final report "*Project Completion Report - Fernald Mixed Waste Stabilization Project*" dated 2/28/97, the following statement is made:

- *Rumors of waste swell related to solidification have been greatly exaggerated*

There is information in common use within DOE and prime contractor ranks that suggests that waste swell due to the addition of pozzolans to hazardous, mixed, and radioactive waste streams can be as much as 100% to 200%. These figures, as assumptions, have been used to estimate the disposed life cycle cost of stabilization to be greater than other more complex technologies. The experience of the Mixed Waste Stabilization Project has demonstrated typical waste swell to be approximately 20%. Higher waste swell factors are typically encountered for salty waste and waste streams having extremely high concentrations of the target contaminant. For the Mixed Waste Stabilization Project, only 7 percent of the legacy waste fell into this category. Another key consideration is the compressive strength desired. Producing a low strength grout, minimizes volumetric swell due to added reagents.

Verification of the above statement can be found in a report entitled "*Letter Report-Minimum Additive Waste Stabilization (MAWS) Technology-Scoping Cost Savings Analysis*" dated 12/10/93, in which the following assumption is made when comparing vitrification to cementation of Waste Pit Material (OU1):

Cementation Scenario

- **The cementation volume factor increase is roughly 3.75.** This is due to the difficulty of immobilizing technetium (Tc99) which is present in the waste, and to achieve a 500 psi grout waste form. Flyash is used as an additive.

As is known, the largest expense item in the life-cycle cost for the Silos Project is the cost to package, ship, and bury the final waste volume. It is also known that the final weight and volume to be disposed of is dependent on the waste loading. Based on the above information and experience at other DOE and commercial sites, calculations comparing waste loading and volume increase were made and are presented in the attached Figure I for Silo 3 waste and attached Figure II for Silos 1 and 2 waste. The starting point for the calculations is presented in the

000108

Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: C1.1

Page 6 of 15

JUSTIFICATION (continued):

attached report entitled *"Determining Solidification Stabilization Quantities for Silos 1 and 2"* prepared by Rod F. Gimple on 12/10/96.

The Gimple report starts with the FS treatability recipe for Silos 1 and 2 waste which produced the 500 psi concrete and passed TCLP. The recipe was adjusted to account for the extra water needed to slurry the material out of the silos and was presented to the IRT. Based on the adjusted FS recipe with a 20% waste loading, the IRT was told that the final cemented volume of Silos 1 and 2 waste would increase from the original 8,890 cubic yards to 30,300 cubic yards. The waste would then be placed in shielded containers (6" thick concrete) to produce a final disposal volume of 101,400 cubic yards for burial. The material inside the container would undoubtedly have greater than 500 psi compressive strength.

The IRT waste loadings were combined with the calculations based on the Silo 3 cementation work at NFS and the mixed wasted cementation work at FEMP to produce the realistic plots of the relationship between % waste loading and volume increase (cost) for the silos. Based on the possible expectation of 80% or greater waste loadings, and the valid unsolicited proposal to treat and dispose of Silo 3 for \$15M, it can be shown that waste from all three silos can be treated and disposed of for less than \$100M rather than the \$479M presented to the IRT for cementation or the \$541 M presented to vitrify Silos 1 and 2 waste while cementing Silo 3 waste.

As is documented in other portions of this VE study, the processing of the 13,900 cubic yards of silo waste through a properly designed, commercially available, stabilization/solidification facility can easily be achieved in a matter of months of operation rather than the years required by vitrification. By quickly processing and staging the sealed boxes of treated waste onsite for controlled shipment, the OH Ten Year Vision can still be realized in a safer, better, faster, and cheaper manner.

000109

Project EM - Phase 2 Report
 Fernald Environmental Management Project
 OU4 Vitrification and Potential Alternatives

SILOS 1 & 2

TABLE 5-6

SUBUNIT A ALTERNATIVE COSTS

Alternative	COSTS			
	Capital	O&M During Remediation	Post- Remediation O&M	Total Present Worth
0A	0	0	0	0
2A/Vit	36,537,400	11,692,500	3,425,400	43,601,900
2A/Cem	71,238,200	11,715,700	3,582,000	74,038,600
3A.1/Vit	38,304,500	11,692,500	0	43,730,700
3A.1/Cem	71,843,300	11,715,700	0	73,086,300

← VIT
 ← Cement

*Values are given in dollars (\$).

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Project EM - Phase 2 Report
 Fernald Environmental Management Project
 OU4 Vitrification and Potential Alternatives

SILLO 3

TABLE 5-8

SUBUNIT B ALTERNATIVE COSTS

Alternative	COSTS			
	Capital	O&M During Remediation	Post- Remediation O&M	Total Present Worth
0B	0	0	0	0
2B/Vit	25,221,500	4,923,000	3,162,000	27,971,300
2B/Cem	35,932,600	4,923,000	3,207,000	37,358,600
3B.1/Vit	26,779,800	4,923,000	0	28,026,400
3B.1/Cem	36,782,300	4,056,000	0	35,964,600
4B	21,825,300	1,094,000	3,207,000	22,045,600

← VIT
 ← Cem. Env.

*Values are given in dollars (\$).

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Project EM - Phase 2 Report
 Fernald Environmental Management Project
 OU4 Vitrification and Potential Alternatives

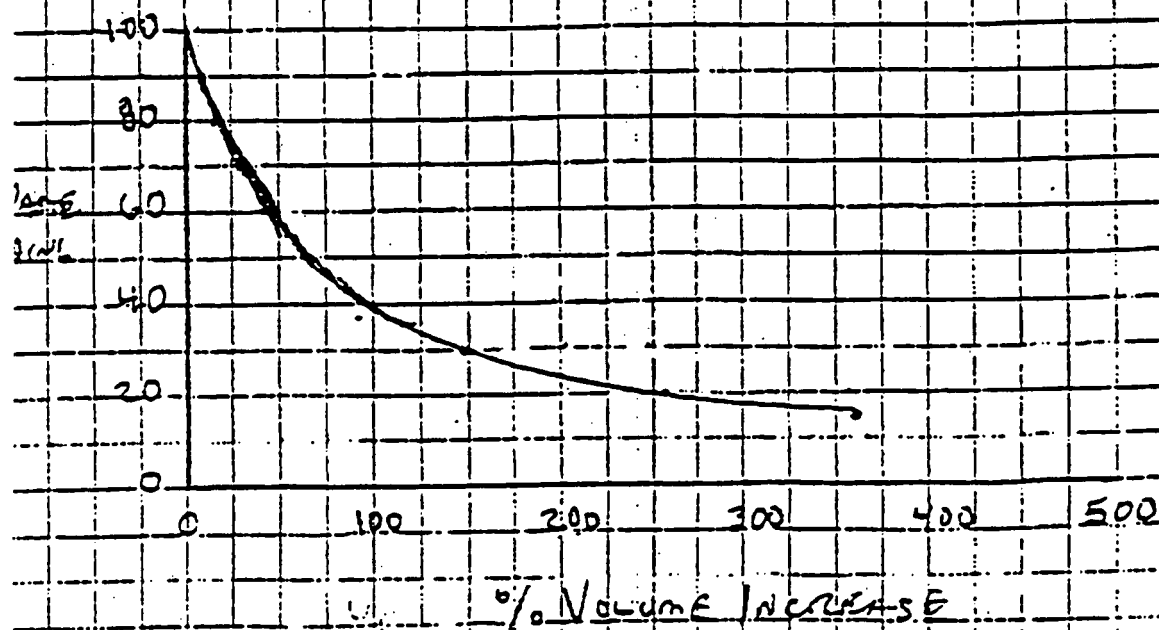
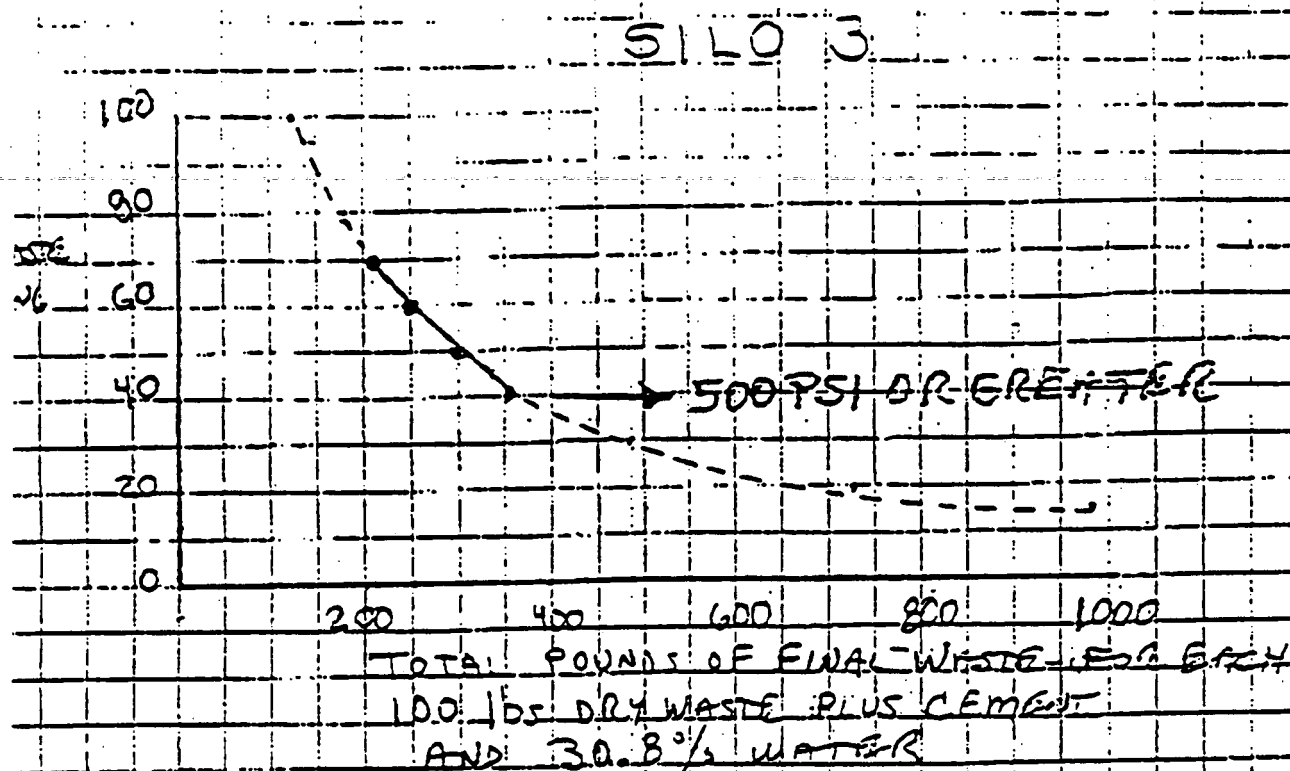
TREATABILITY DATA FROM NFS
 ON SILO 3 RETAINS

MIX DESIGN MATRIX					
Binder Type	Material to Binder Ratio (wt%)				Pretreatment (y/n)
	Mix 1	Mix 2	Mix 3	Mix 4	
Portland Type I	0.4 Test 1	0.5 Test 2	0.6 Test 3	0.7 Test 4	a
Aquasol II H	0.5 Test 5	0.6 Test 6	0.7 Test 7	0.8 Test 8	a
Portland Type I	0.4 Test 9	0.5 Test 10	0.6 Test 11	0.7 Test 12	y
Aquasol II H	0.5 Test 13	0.6 Test 14	0.7 Test 15	0.8 Test 16	y

TEST DATA										
Test #	Crush Strength (psi)	Density (g/cc)	TCLP Metals (ppm)							
			Ag	As	Ba	Cd	Cr	Hg	Pb	Se
Initial	na	na	<0.002	0.194	0.259	0.004	6.055	<0.01	<0.02	0.623
1	500	1.32	<0.002	0.020	0.572	<0.002	1.325	<0.01	<0.025	0.093
2	363	1.76	0.085	0.046	0.470	<0.002	1.509	<0.01	<0.025	0.125
3	129	1.73	<0.002	0.049	0.351	<0.002	1.790	<0.01	<0.025	0.242
4	85	1.63	<0.002	0.139	1.051	<0.002	2.269	<0.01	<0.025	0.311
5	82	1.37	<0.002	0.139	1.940	<0.002	1.487	<0.01	<0.025	0.170
6	28	1.41	<0.002	0.314	0.156	<0.002	1.773	<0.01	<0.029	0.370
7	32	1.44	<0.002	0.235	0.144	<0.002	2.415	<0.01	<0.029	0.422
8	32	1.46	<0.002	0.442	0.112	<0.002	2.719	<0.01	<0.029	0.594
9	116	1.69	<0.002	0.026	0.687	<0.002	0.584	<0.01	<0.029	0.175
10	227	1.73	<0.002	0.026	0.202	<0.002	0.823	<0.01	<0.029	0.224
11	70	1.66	<0.001	0.041	0.113	<0.001	0.715	0.018	<0.012	0.274
12	56	1.64	<0.001	0.117	0.107	<0.001	0.907	<0.01	<0.012	0.355
13	54	1.38	<0.001	0.095	0.117	<0.001	0.404	<0.01	<0.012	0.161
14	28	1.38	<0.001	0.157	0.151	<0.001	0.742	<0.01	<0.012	0.262
15	20	1.42	<0.001	0.380	0.078	<0.001	0.364	<0.01	<0.012	0.284
16	15	1.46	<0.001	0.422	0.076	0.002	0.254	<0.01	<0.012	0.543

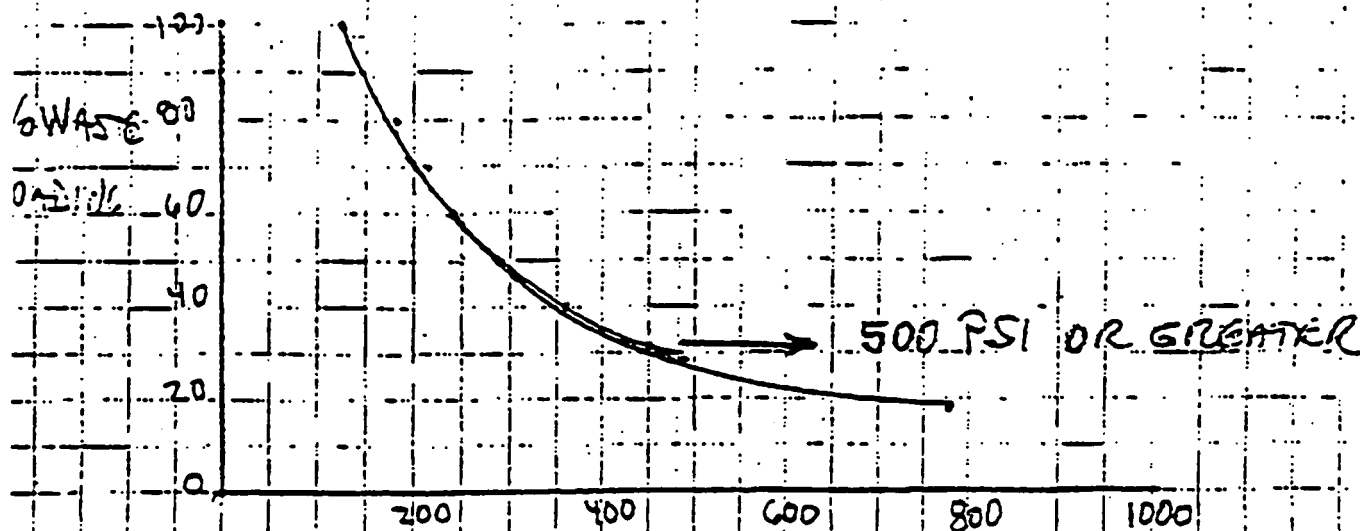
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Project EM - Phase 2 Report
 Fernald Environmental Management Project
 OU4 Vitrification and Potential Alternatives

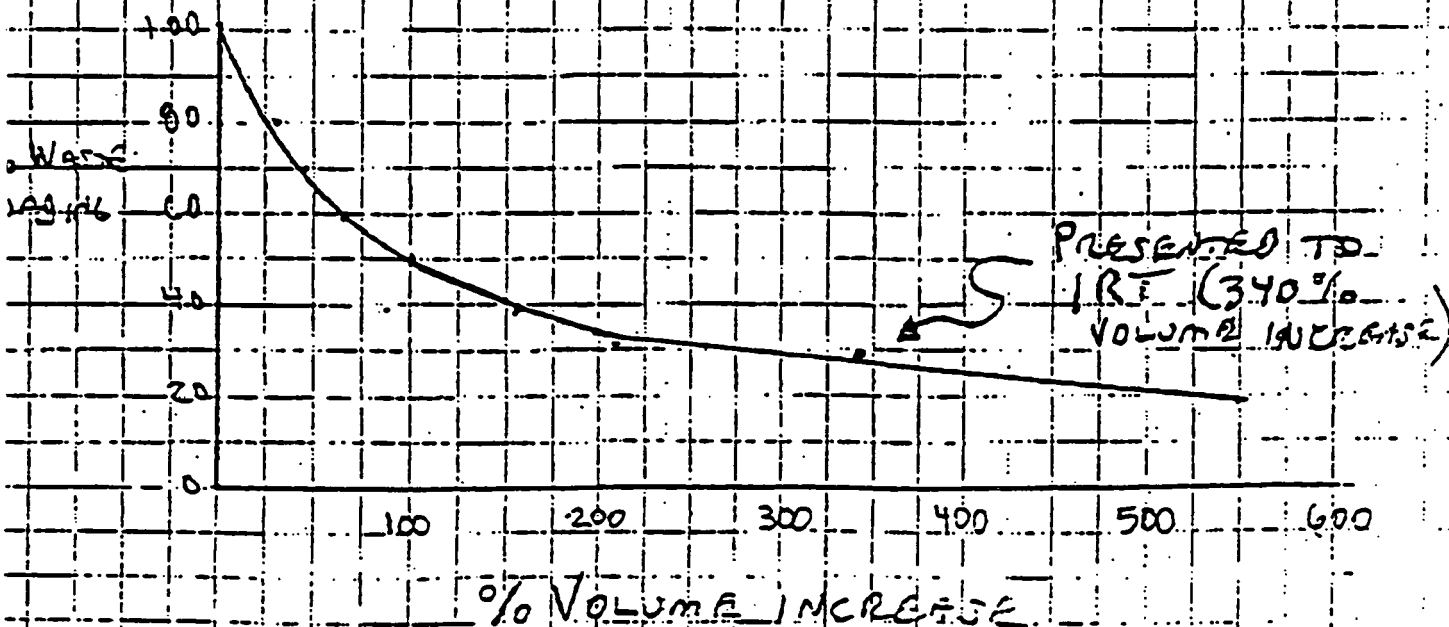


Project EM - Phase 2 Report
 Fernald Environmental Management Project
 OU4 Vitrification and Potential Alternatives

SILLOS 1.42



TOTAL POUNDS OF FINAL WASTE FOR EACH
 100 LBS DRY WASTE PLUS CEMENT/FLYASH
 AND 30.3% WATER



Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

Rod F. Gimpel
12/10/96

Determining Solidification Stabilization Quantities for
Silos 1 and 2

Fernald Silo In Situ Waste Quantities:

Silo 1 waste residues	7,642
Silo 2 waste residues	<u>6,620</u>
	14,262
 Silo 1 bentonite cap	 630
Silo 2 bentonite cap	<u>555</u>
	1,118
 Total	 15,447 (10,813 dry)

Treated Waste Amount:

Solidification stabilization formulas developed for Silos 1 and 2 are given in Tables 3-7 and 3-8 within "Treatability Study Report Operable Unit 4" dated March 1993. The following solidification calculations are based on Run No. 2 as shown in Table 3-7 of the treatability study. The treatability formulas were based on "mined" in situ moistures. The average moisture was assumed to be 30 wt% in the treatability study. However, plans are to remove the wastes as a slurry during remediation of the silos. The remedial slurry system is assumed to handle and deliver a feed with 30 to 40 wt% solids.

Table 1 shows the Run No. 2 formula adjusted for a slurry feed system handling 40 wt% solids. Table 2 shows the same data adjusted for a slurry feed system handling 30 wt% solids. The 30 wt% solids handling may be the more realistic expected value. The OU4 Pilot feed system handled an average of 34 wt% solids during Campaign 2 and during Campaign 4, thus far, it has handled approximately 35 wt% solids. However, the 34 and 35 wt % solids contain 32 % (11 wt% absolute) soluble compounds (potassium carbonate, potassium nitrate, lithium carbonate, sodium carbonate, sodium nitrate, and boric acid). Therefore, the effective wt% solids physically handled by the system is less - it would be 23 and 24 wt% if all the soluble materials were dissolved in the water. Also, bentonite has not been used in Campaigns 2 or 4 thus far. Its presence may lower the wt% solids handling capacity of the feed system.

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Project EM - Phase 2 Report
 Fernald Environmental Management Project
 OU4 Vitification and Potential Alternatives

Table 1
 Run No. 2 with 40 wt%

Component	Treatability Report Run 2 Formula, lbs	Slurry Feed 40 wt% Solids, lbs	Run 2 Formula Adjusted, lbs	Run 2 Formula Adjusted 100 lbs basis, lbs
Waste (dry basis)	70	70	70	100
Type 2 portland cement	68		73.61	105.16
Type F Flyash	68		73.61	105.16
Attapulgate	6		6.49	9.27
Clinoptilolite	6		6.49	9.27
Water	97 (30 from waste)	105	105	150
Sand*	—		5.8	8.29
Total	315	175	341	487.15
wt % moisture	30.8	60	30.8	30.8

Stabilized waste produced = 54,000 tons. Bulking factor = 500 wt%.

*Sand is shown because it is inert. One of the other components possibly could be used.

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Project EM - Phase 2 Report
 Fernald Environmental Management Project
 OU4 Vitrification and Potential Alternatives

Table 2
 Run No. 2 with 30 wt%

Component	Treatability Report Run 2 Formula, lbs	Slurry Feed 30 wt% Solids, lbs	Run 2 Formula Adjusted, lbs	Run 2 Formula Adjusted 100 lbs basis, lbs
Waste (dry basis)	70	70	70	100
Type 2 portland cement	68		116.6	166.57
Type F flyash	68		116.6	166.57
Attapulgit	6		10.29	14.7
Clinoptilolite	6		10.29	14.7
Water	97 (30 from waste)	166.33	166.33	237.61
Sand*	-		49.89	71.27
Total	315	233.33	540	771.42
wt % moisture	30.8	70	30.8	30.8

Stabilized waste produced = 83,000 tons. Bulking factor = 750 wt%.

*Sand is shown because it is inert. One of the other components possibly could be used.

Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

FORM: 30 DEC 1996

COST ESTIMATE - FIRST COST

IDENTIFICATION NUMBER: C1.1

Page 15 of 15

Cost Item	Units	Unit Cost		Original Design		Recommended Design	
		\$/Unit	Source Code	Num of Units	Total \$	Num of Units	Total \$
Bury Waste			1				
Silos 1 and 2			1		11,700,000		
Bury Silo 3			1		10,000,000		
Design and Build Vit			1				
Operate Vit			1				
D & D Vit			1				
Landlord			1		75,000,000		
Bury Silos 1&2 waste at 70% solids			1				65,000,000
Bury Silo 3			1				10,000,000
Design and Build			1				
Totals					96,700,000		75,000,000

SOURCE CODE: 1 Project Cost Estimate
 2 CES Data Base

4 Means Estimating Manual
 5 Richardson's (List job if applicable)

7 Professional Experience

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3 CACES Data Base

6 Vendor Lit or Quote (list name / details)

8 Other Sources (specify)

Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

FORM 20 DEC 1996

PROJECT: Critical Analysis of OU4 Vitrification and Potential Alternatives

Page 1 of 5

LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997

IDENTIFICATION NUMBER: C1.2

FUNCTION OF COMPONENT BEING CHANGED: Treat Contents

DESCRIPTIVE TITLE OF RECOMMENDATION: Processing Rate

ORIGINAL DESIGN:

The design rate for processing Silos 1, 2, and 3 contents through parallel vitrification units is 18 tons per day. The existing Marconoflow pump operates at 140 gallons per minute at 20% solids. The pump solids delivery rate is $0.2 \times 140 \text{ gallons/minute} \times 8.34 \text{ lbs/gal} \times 1 \text{ ton/2000 lbs} \times 60 \text{ min/hour} = 7.0 \text{ tons/hour}$. At the $3/4$ ton/hour rate of processing, the pump would operate for 3 hours/day. The pump discharge would sit full of solids for the remaining 21 hours each day.

RECOMMENDED CHANGE:

Process the contents of Silos 1, 2, and 3 at a rate approximately equal to the pumping rate.

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VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: C1.2

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ADVANTAGES:

- Bottlenecks are eliminated.
- Line plugging will be minimized.
- The hazardous properties of silos 1, 2, and 3 contents will be reduced faster.

DISADVANTAGES:

- Requires a change to the Record of Decision (ROD).
- Incompatible with vittrification, only compatible with stabilization.
- Additional on-site storage may be required because of proposed waste shipping schedules.

JUSTIFICATION:

Standard equipment for solidification/stabilization normally operates at processing rates exceeding 10 tons per hour.

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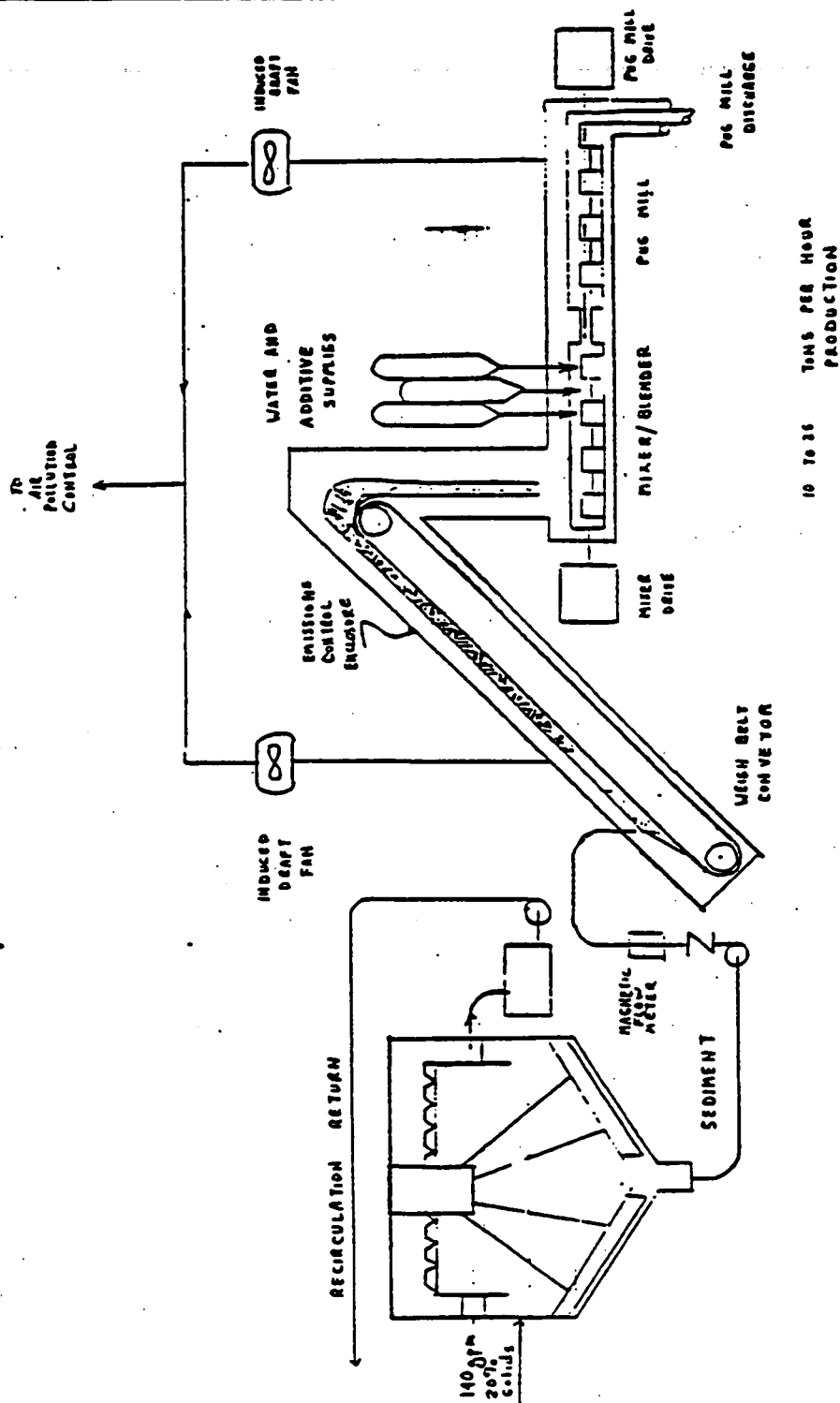
VALUE ENGINEERING RECOMMENDATION

FORM 20 DEC 1966

SKETCH OF RECOMMENDED DESIGN

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SKETCH OF RECOMMENDED DESIGN

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Plant Size

C1

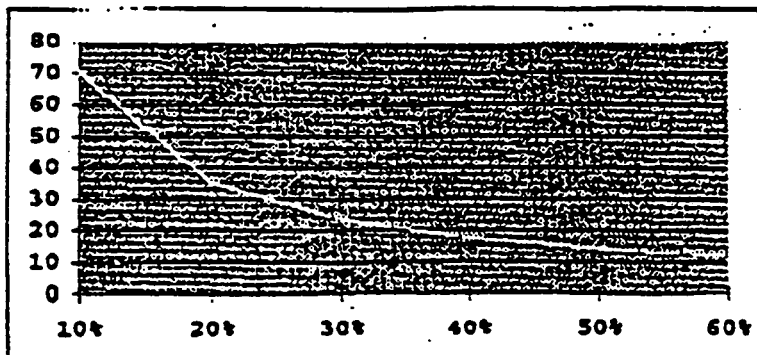
Treatment Plant Sizing
 Based on Pumping Rate

140 gpm @	20% solids	40% solids
8.34 lb/gal	8.34 lb/gal	8.34 lb/gal
60 min/hr	60 min/hr	60 min/hr
2,000 lb/ton	2,000 lb/ton	2,000 lb/ton
35 ton/hr	7 ton/hr	7 ton/hr
0.69 cu.yd./hr	0.69 cu.yd./hr	0.347 cu.yd./hr

Waste

Loading

10%	70 ton/hr
20%	35 ton/hr
30%	23 ton/hr
40%	18 ton/hr
50%	14 ton/hr
60%	12 ton/hr



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VALUE ENGINEERING RECOMMENDATION

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CALCULATIONS

IDENTIFICATION NUMBER: C1.2

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Original Design
Pumping Rate (Solids)
$140 \text{ gpm} \times 20\% \times 8.34 \text{ lbs/gal} \times 1 \text{ ton}/2000 \text{ lbs} \times 60 \text{ min/hour} = 7 \text{ tons/hour}$
Processing Rate (Solids)
18 tons/day (3-6 ton units)
$3/4 \text{ tons/hour}$
Proposed Design
$7 \text{ tons/hour pumping rate} = 7 \text{ tons/hour treatment rate}$

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FORM 20 DEC 1996

PROJECT: Critical Analysis of OU4 Vitrification and Potential Alternatives

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LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997

IDENTIFICATION NUMBER: C4.1

FUNCTION OF COMPONENT BEING CHANGED: Melter Waste Form

DESCRIPTIVE TITLE OF RECOMMENDATION: "Gems" to "Monolith"

ORIGINAL DESIGN:

It is planned to flow glass from the melter to a gem producing machine. Gems would then be moved to a shielded shipping container which would also be the shipping container.

RECOMMENDED CHANGE:

Change the vitrified product to a monolith with its dimensions optimized for loading into a shipping container/shield or pour directly into a metal box.

SUMMARY OF COST ANALYSIS			
	First Cost	O & M Costs (Present Worth)	Total LC Cost (Present Worth)
ORIGINAL DESIGN	0	0	0
RECOMMENDED DESIGN *	0	(20,000,000)	(20,000,000)
ESTIMATED SAVINGS OR (COST)	0	20,000,000	20,000,000

* \$5 million in schedule and \$15 million in packaging/shipping/disposal

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IDENTIFICATION NUMBER: C4.1

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ADVANTAGES:

- In a monolith the void volume is largely eliminated - approximately 25-30% less volume for vitrified monolith waste compared to gems.
- Less sensitive to pour fluctuations (rate/viscosity/temperature)
- Less leachable surface area and also reduced radon emanation.
- No significant maintenance for a monolith system. At SRO and in pilot operation at FERMCO there has been maintenance and operational problems with the gem machine. At SRO, the gem machine has been a major contributor to limiting the melter capacity.
- Less cost due to all of the above - specific saving resulting from time duration and higher output, shipping and disposal of lower volumes, and lower maintenance costs (dollars and ALARA).

DISADVANTAGES:

- May require more melt formulation changes to mitigate phase separation.
- Require additional engineering for monolith form optimization and handling procedures.
- Potentially more difficult to handle/recycle off-spec product.
- May require new/modified shipping/disposal casks.
- Slow cooling process. May require controlled cooling and larger cooling building.

JUSTIFICATION:

- Reliability and ease of operation.
- Cost savings -Capital, Schedule, Packaging, Shipping, Disposal
Capital- Current basis for a 6 ton/day melter is \$3 million, including three gem machines, one for each melter. There are no details for the distribution of this \$3 million, but a relatively small fraction of the cost would be the three gem machines. Some of these savings would be put back for a canister/loading handling system. No important savings.

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VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: C4.1

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JUSTIFICATION (continued):

Schedule - Based on the history of gem machine maintenance and bottlenecks, productivity had been reduced. Therefore it would be prudent to assume a longer production period, e.g., 5% loss in production would result in an increase in the scheduled 4 year production period. This would result in a cost increase of \$ 5 million based on historical hotel costs of \$25 million/year. This increase would not occur in a monolith system.

Packaging/Shipping/Disposal - Total for gems \$80 million. The monolith for these functions is 70% of the gem waste volume because shipping /storage requires the same shielding. The overall volume savings is less than 30%. To account for this reduction, a value of 20% was assumed which would result in \$15 million savings.

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LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997

IDENTIFICATION NUMBER: C4.2

FUNCTION OF COMPONENT BEING CHANGED: Waste Glass Melting

DESCRIPTIVE TITLE OF RECOMMENDATION: Design , Purchase, and Utilize a "Proven" Melter

ORIGINAL DESIGN:

Six ton/day, 1150 degrees Celsius glass melter (see pilot melter history in justification section)

RECOMMENDED CHANGE:

Change to a fully tested and proven design (see point by point discussion). A proven design for the proposed capacity change requires a full scale melter test program.

JUSTIFICATION:

Pilot Melter History

The pilot plant melter, which was planned as a "proof of design" for the production melter failed in the testing period because of several, beyond-current-technology, features. Specifically as a result of a higher-than-normal operating temperature (e.g., 1300+ degrees Celsius) as required by the sulphur content and chemical composition of Silo 3, a three chamber melter was designed so that non-corrosive glass would surround the molybdenum electrodes. In addition, multiple bottom pipe penetrations were specified, a design feature not incorporated in other melter designs. Due to the design and operating conditions, this nominal 1 ton/day melter failed

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VALUE ENGINEERING RECOMMENDATION

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JUSTIFICATION (continued):

after 6 months of operations with surrogate materials. During this period, significant information was learned about the impacts of lead and sulfates on the melter design and construction. Many abnormal events occurred indicating a need for significant testing of any new melter design.

Production Melter Requirements

The reference design for the production facility is three parallel melter lines each having a capacity of 6 tons/day. The major technical concern is the high melter throughput which is 2 to 6 times the rate of melters used in radioactive waste applications. Demonstration of success at this capacity is needed not only for melting, but also for feed control, discharge flow, and off-gas treatment.

At other DOE sites, before a production facility design has been finalized, a prototype (essentially a full scale melter), has had a development/testing/demonstration period of 5 (West Valley 1 ton/day) to 10 years (SRO 1-3 tons/day). In both of these programs, because the vitrification was of high level waste, the consequence of melter failure after hot operation would be disastrous, hence maximum reliability was required. There is a similar but much less severe maintenance ALARA issue with K-65 wastes at FERMCO.

Independent of the major leak failure, as a direct result of bottom penetrations and of the high temperature operation many other problems/failures developed in the 6 month pilot program. These failures included discharge control (auto-discharge), unexplained loud noise, inoperable bubblers, cooling jacket failure, foaming, and "glowing" solid glass plugging. For some of these events a root cause was not identified. The number of events and their attempted fix demonstrates the need for a significant test period to first identify and then modify the melter to eliminate future events. Demonstration of proven melter technology will require:

- A correlation of design features and parameters to other proven designs.
- Early procurement of one melter designed for the production rate of 6 tons/day.
- The operation of the first melter for a minimum of 6 months, more likely 1-1.5 years. For this operation the conceptual monolith glass handling need not be final engineered, but the

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JUSTIFICATION (continued):

off-gas system must be tested at this full rate. The design for the radon system must be engineered so that this "test" melter can be used as the first unit of the production line, but the radon system need not be installed.

- After design modifications are developed, procure two additional melters and proceed with final design and construction of the production facility.

If the above, or similar were followed, the resultant vitrification production schedule would be delayed for a minimum of two years and probably longer. This time delay is developed from a time-line estimated as follows:

- Melter design and purchase specification - 8 to 12 months. This time frame is currently accounted for to some extent in the reference schedule so it may not be a direct adder.
- Melter purchase, manufacturing and pilot facility design - 12 months. This is an adder as it represents an additional step, the design and building of a pilot facility that is convertible to a melter line in the production facility.
- Melter pilot operation - 6 to 12 months. This time period is an estimate based on experience at other sites and is intended to provide sufficient data on long-term operability.
- Fabrication of revised melter design - 12 months. This period is an added delay in order to use the lessons learned in the pilot program.

Based on the above program modifications there are cost additions which are estimated as follows:

- Melter design - no significant change.
- Melter purchase and pilot facility design and construction - time of 12 months at \$25 million total costs.
- Melter pilot operation - 12 months addition at an operating cost of \$12 million and time extension at \$25 million.
- Fabrication of production melters - 12 months at \$25 million.

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JUSTIFICATION (continued):

Based on these estimates the total vitrification project would be extended for up to 36 months with an associated cost increase of approximately \$85 million.

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LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997

IDENTIFICATION NUMBER: C5.1

FUNCTION OF COMPONENT BEING CHANGED: Pack Waste

DESCRIPTIVE TITLE OF RECOMMENDATION: Solidification

ORIGINAL DESIGN:

Assumed waste loading of Silos 1 and 2 treated product to be 20%. Silo 3 is assumed to be 45%.

RECOMMENDED CHANGE:

Increase waste loading for Silos 1 & 2 waste from 20% to 45% similar to Silo 3.

SUMMARY OF COST ANALYSIS			
	First Cost	O & M Costs (Present Worth)	Total LC Cost (Present Worth)
ORIGINAL DESIGN	237,788,000	0	237,788,000
RECOMMENDED DESIGN	105,683,000	0	105,683,000
ESTIMATED SAVINGS OR (COST)	132,105,000	0	132,105,000

VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: C5.1

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ADVANTAGES:

- Reduces overall time for treating Silos 1 and 2 waste.
- Reduces number of waste containers required.
- Reduces number of shipments needed and transportation costs.
- Reduces disposal costs.
- Reduces on-site interim waste storage requirements.
- Reduces on-site waste handling requirements.

DISADVANTAGES:

- Requires developing mix recipes and performing proof tests.
- Concentration of radioactive material is higher (possibly a safety concern for workers).
- Concentration of metals in the waste foam is higher and therefore may be more difficult to pass TCLP.
- Compressive strength of waste is lower (which is currently not an issue for shipping and disposal).
- Temporary storage of treated waste will be necessary in order to keep waste transport from controlling the treatment throughput.

JUSTIFICATION:

Utilizing solidification as a treatment for Silo 3 waste apparently achieves a 45% waste loading factor. It is assumed that the same waste loading factor could be achieved for Silos 1 & 2 waste with development of mix recipes. By achieving this waste loading, treatment time is decreased and the number of waste containers is reduced by a factor of 2.25.

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CALCULATIONS

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Assume 45% Waste Loading
20% (x) = 45% (Based % weight)
x = 2.25
1.) Volume of treated waste
@ 20% W.L. Original quantity - 33,500 cy
@ 45% W.L. Revised quantity - 14,888 cy
2.) Number of containers
Original quantity - 20,700
@ 45% W.L. Revised quantity - 9,200
3.) Number of waste shipments
Original quantity - 10,350
@ 45% W.L. Revised quantity - 4,600
4.) Reduction in operations time
Original time - 3 years
@ 45% W.L. Operational time - 1.3 years

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FORM: 30 DEC 1996

COST ESTIMATE - FIRST COST

IDENTIFICATION NUMBER: C5.1

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Cost Item	Units	Unit Cost		Original Design		Recommended Design	
		\$/Unit	Source Code	Num of Units	Total \$	Num of Units	Total \$
Containers	EA	4,746	1	20,700	98,242,000	9,200	43,663,000
Shipments	EA	3,584	1	10,350	37,094,000	4,600	16,486,000
Operation	MO	805,000	1	36	28,980,000	16	12,880,000
Project Management	MO	313,000	1	36	11,268,000	16	5,008,000
Disposal	EA	3,005	1	20,700	62,204,000	9,200	27,646,000
Total					237,788,000		105,683,000
Assumptions: Project management monthly cost was based on \$45,000,000 for 12 year							
duration. \$313,000/month							

SOURCE CODE: 1 Project Cost Estimate
 2 CES Data Base
 3 CACES Data Base

4 Means Estimating Manual
 5 Richardson's
 6 Vendor Lit or Quote (list name / details)

7 Professional Experience
 (List job if applicable)
 8 Other Sources (specify)

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VALUE ENGINEERING RECOMMENDATION

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PROJECT: Critical Analysis of OU4 Vitrification and Potential Alternatives

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LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997

IDENTIFICATION NUMBER: C5.2

FUNCTION OF COMPONENT BEING CHANGED: Waste Packaging

DESCRIPTIVE TITLE OF RECOMMENDATION: Control Radon

ORIGINAL DESIGN:

Vitrify all silo waste as selected treatment method. Package treated waste in SEG boxes. This method meets or exceeds a) all treatment, packaging, transportation requirements; b) waste disposal site WAC; and c) radiation requirements. This solution also adequately addresses radon containment.

RECOMMENDED CHANGE:

Stabilize Silos 1 and 2 waste (K-65), place in shipping container, and transport for disposal at NTS. Add activated carbon to shipping package to retard radon release.

NOT COSTED - SEE RECOMMENDATION D1.1

ADVANTAGES:

- Assures radon retention and control.
- Provides sufficient delay time to permit radon decay.

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DISADVANTAGES:

- Must add activated carbon to the treated waste package.
- Amount of carbon required must be determined.
- May slightly reduce the amount (volume) of waste that can be placed in each waste box which would result in an increase in the amount of waste to be disposed of.

JUSTIFICATION:

One of the disadvantages of solidified waste is that, unlike vitrified waste, radon can escape from the solidified product. This makes packaging solidified waste in an air tight container important in order to reduce the chance for radon release during handling, storage and shipment. The containers must withstand some minimal internal pressure, and the containers will tend to flex with changes in ambient conditions. The recommendation is to add a bed of carbon on top of the stabilized waste within the container to capture the radon before it can escape through any gaps that may occur between the lid and lid seat (see Proposal D1.1).

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LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997

IDENTIFICATION NUMBER: C5.3

FUNCTION OF COMPONENT BEING CHANGED: Feed Stream

DESCRIPTIVE TITLE OF RECOMMENDATION: Reduce Volume

ORIGINAL DESIGN:

Treat, package, and dispose of Silos 1 and 2 bentonite cap along with the K-65 waste.

RECOMMENDED CHANGE:

Remove the relatively uncontaminated bentonite cap from Silos 1 and 2 prior to removing K-65 waste. Dispose of bentonite as uncontaminated waste in the onsite underground storage disposal facility.

ALTERNATIVE 2

SUMMARY OF COST ANALYSIS			
	First Cost	O & M Costs (Present Worth)	Total LC Cost (Present Worth)
ORIGINAL DESIGN	65,244,000	0	65,244,000
RECOMMENDED DESIGN	65,399,000	0	65,399,000
ESTIMATED SAVINGS OR (COST)	(155,000)	0	(155,000)

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VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: C5.3

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ALTERNATIVE 3

SUMMARY OF COST ANALYSIS			
	First Cost	O & M Costs (Present Worth)	Total LC Cost (Present Worth)
ORIGINAL DESIGN	226,520,000	0	226,520,000
RECOMMENDED DESIGN	210,025,000	0	210,025,000
ESTIMATED SAVINGS OR (COST)	16,495,000	0	16,495,000

ADVANTAGES:

- Reduce the time and cost of treating, packaging, transporting, and disposing of the Silos 1 and 2 wastes.

DISADVANTAGES:

- Must develop a method of removing the bentonite.
- Must dispose of the bentonite through some other means.
- Bentonite must be removed separately from the K-65 material. The site has indicated that the bentonite is not a smooth layer which can be easily scraped off. It is unlikely that the bentonite could be retrieved without also retrieving some of the K-65 material.
- Bentonite will contain some contamination from radon decay.
- May not meet on-site disposal acceptance criteria.

JUSTIFICATION:

A significant cost and schedule benefit could be realized if the top layer, the bentonite cover cap, could be removed and treated as uncontaminated or less hazardous waste than the K-65. In 1991,

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IDENTIFICATION NUMBER: C5.3

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JUSTIFICATION (continued):

approximately 878 cubic yards of bentonite was placed in Silos 1 and 2 as a cover cap to contain radon that was given off by the K-65 materials stored below. Today this cover cap represents 11% of the volume of materials needing treatment. This translates into 11% of the costs for:

- Treatment facility operating time
- Waste packaging
- Waste containers
- Waste handled and transported
- Waste disposed for solidification

This bentonite volume, however, amounts to only 3% of the Silo's volume after vitrification because bentonite is comprised of about 70% water which will evaporate during the vitrification process.

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CALCULATIONS

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Assumptions:
1.) Only 75% of the bentonite will be retrievable, resulting volume = 660 cy = 8.2% of total volume of material.
2.) No input on overall schedule because material must still be removed from tanks. Hence, no impact on project management.
3.) Bentonite disposal on-site.
4.) For bentonite retrieval
Capital Equipment Allowance - \$1,000,000
Operation = 10,000/day x 5 days/week x 12 weeks - \$600,000
Engineering 30% - \$480,000
Total - \$2,080,000

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COST ESTIMATE - FIRST COST

IDENTIFICATION NUMBER: C5.3

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Cost Item	Units	Unit Cost		Original Design		Recommended Design	
		\$/Unit	Source Code	Num of Units	Total \$	Num of Units	Total \$
Alternative 2							
Containers	EA	4,746	1	3,800	18,035,000	3,686	17,494,000
Shipments	EA	3,584	1	1,900	6,810,000	1,843	6,605,000
Vit. Operation	MO	805,000	1	36	28,980,000	35	28,111,000
Disposal	EA	3,005	1	3,800	11,419,000	3,686	11,076,000
Bent. Disposal	CY	49.3	1	0	0	660	33,000
Bent. Retrieval	LOT	2,080,000	7	0	0	1	2,080,000
Totals					65,244,000		65,399,000

SOURCE CODE: 1 Project Cost Estimate

2 CES Data Base

3 CACES Data Base

4 Means Estimating Manual

5 Richardson's

6 Vendor Lit or Quote (list name / details)

7 Professional Experience

(List job if applicable)

8 Other Sources (specify)

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VALUE ENGINEERING RECOMMENDATION

FORM: 30 DEC 1996

COST ESTIMATE - FIRST COST

IDENTIFICATION NUMBER: C5.3

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Cost Item	Units	Unit Cost		Original Design		Recommended Design	
		\$/Unit	Source Code	Num of Units	Total \$	Num of Units	Total \$
Alternative 3							
Containers	EA	4,746	1	20,700	98,242,000	19,003	90,188,000
Shipments	EA	3,584	1	10,350	37,094,000	9,502	34,055,000
Vit. Operation	MO	805,000	1	36	28,980,000	33	26,565,000
Disposal	EA	3,005	1	20,700	62,204,000	19,003	57,104,000
Bent. Disposal	CY	49.3	1	0	0	660	33,000
Bent. Retrieval	LOT	2,080,000	7	0	0	1	2,080,000
Totals					226,520,000		210,025,000

SOURCE CODE: 1 Project Cost Estimate 4 Means Estimating Manual 7 Professional Experience
2 CES Data Base 5 Richardson's (List job if applicable)
3 CACES Data Base 6 Vendor Lit or Quote (list name / details) 8 Other Sources (specify)

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LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997

IDENTIFICATION NUMBER: C5.4

FUNCTION OF COMPONENT BEING CHANGED: Mix Waste Concrete

DESCRIPTIVE TITLE OF RECOMMENDATION: Stabilization/Solidification

ORIGINAL DESIGN:

Design/Construct two cementation batch plants of differing capacity (8.0 cy/hr and 12 cy/hr) to treat Silos 1, 2, and 3 waste. These plants are scheduled to operate 8 hours/day and 5 days/week for 3 years 9 months.

RECOMMENDED CHANGE:

Procure (design and construction) one batch plant sized to handle the larger of the two waste streams. The design of this plant would address all the shielding, ventilation, and technical requirements for Silos 1 and 2 waste. Operate plant 16 or 24 hrs/day for approximately 1.3 years (assuming 80% availability).

BASED ON CASE B

SUMMARY OF COST ANALYSIS ¹			
	First Cost	O & M Costs (Present Worth)	Total LC Cost (Present Worth)
ORIGINAL DESIGN	133,900,000	0	133,900,000
RECOMMENDED DESIGN	60,227,000	0	60,227,000
ESTIMATED SAVINGS OR (COST)	73,673,000	0	73,673,000

¹Cost Table based on 16 hours per day operation.

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VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: C5.4

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ADVANTAGES:

- Eliminates the need to design, construct and procure a second batch plant.
- Operating a plant on 24 hours/day reduces life-cycle costs substantially.
- Reduces amount of equipment to be D & D'd.
- Eliminates redundant site support efforts: equipment procurement, off-gas cleanup, ORR, training, site preparation and utilities.
- Eliminates potential of another contractor being selected for second cement plant.
- Reduces waste processing time.
- Better matches a production facility operating schedule.

DISADVANTAGES:

- Would result in waste being treated in series (Silos 1 & 2 after Silo 3).
- Temporary storage of treated waste will be necessary in order to keep transport from controlling the treatment throughput.

JUSTIFICATION:

Utilizing solidification through cementation as a means for stabilizing the silos waste requires minor modifications to a proven technology. Operation of a batch plant type facility 24 hours a day is not uncommon. Shutting down an operating facility and procuring and operating a similar (identical) facility is not logical or justified. A single, continuously operating facility also completes OU4 waste treatment much more rapidly.

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CALCULATIONS

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(Calculation #1 Silo 1 & 2 mixture)
$85 \text{ MT/day} \times 2200 \text{ lbs/1 MT} \times 1 \text{ day/8 hrs} \times 1 \text{ ton/2000 lbs} = 11.69 \text{ ton/hr} \Rightarrow 12 \text{ ton/hr}$
(Calculation #2 Silo 3)
$119 \text{ MT/day} \times 2200 \text{ lbs/1 MT} \times 1 \text{ day/8 hrs} \times 1 \text{ ton/2000 lbs} = 16.36 \text{ ton/hr} \Rightarrow 17 \text{ ton/hr}$
Density of treated waste (calculation #1)
$\text{Dry} - 90 \text{ lb/ft}^3 \times 1 \text{ ton/2000 lbs} \times 27 \text{ ft}^3/\text{1yd}^3 = 1.22 \text{ ton/yd}^3$
$\text{Final Waste} - 114 \text{ lb/ft}^3 \times 1 \text{ ton/2000 lbs} \times 27 \text{ ft}^3/\text{1yd}^3 = 1.54 \text{ ton/yd}^3$
Capacity of Plant (calculation #1)
$1 \text{ yd}^3/1.54 \text{ ton} \times 12 \text{ ton/hr} = 7.79 \text{ cy/hr}$
$\Rightarrow 8 \text{ cy/hr}$
Density of treated waste (calculation #2)
$100 \text{ lbs/ft}^3 \times 1 \text{ ton/2000 lbs} \times 27 \text{ ft}^3/\text{1 yd}^3 = 1.35 \text{ ton/yd}^3$
$1 \text{ yd}^3/1.35 \text{ ton} \times 16.36 \text{ ton/hr} = 12.12 \text{ yd}^3/\text{hr}$

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 Fernald Environmental Management Project
 OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

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CALCULATIONS

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PLANTS AS CURRENTLY DESIGNED:

SILOS 1 & 2

$$\text{RESIDUES} - 8012 \text{ CY} \times \frac{90\%}{\text{CY}} \times \frac{27 \text{ CB}}{\text{CY}} \times \frac{1 \text{ MT}}{2200 \text{ LBS}} = 8850 \text{ MT}$$

$$\text{SCRAP} - 878 \text{ CY} \times \frac{74\%}{\text{CY}} \times \frac{27 \text{ CB}}{\text{CY}} \times \frac{1 \text{ MT}}{2200 \text{ LBS}} = 797 \text{ MT}$$

$$\text{TOTAL MATERIAL IN SILOS 1 & 2} = 9647 \text{ MT (Dry wt.)}$$

FOIL TREATMENT (ASSUMING ALL MATERIAL - RESIDUES & SCRAP - WILL BE TREATED)

$$9647 \text{ MT} \times 20\% \text{ W.L.} = 48235 \text{ MT}$$

$$48,235 \text{ MT} \div 85 \text{ MT/day} = 567 \text{ days}$$

$$567 \text{ days} \times 80\% \text{ avail.} = 708 \text{ days}$$

$$2.72 \text{ yr} = 3 \text{ yrs}$$

* ASSUMES 1 - 8 hr shift / day

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IDENTIFICATION NUMBER: C5.4

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PLANTS AS CURRENTLY DESIGNED:

Silo 3

$$\text{Residue} = 5088 \text{ CY} \times \frac{57 \text{ lb}}{\text{CF}} \times \frac{12 \text{ CF}}{100} \times 1 \frac{\text{MT}}{2200 \text{ lb}} = 3,559 \text{ MT}$$

3,559 MT (Dry Wt.)

FOR TREATMENT

$$3,559 \text{ MT} @ 45\% \text{ U.L.} \Rightarrow 7,908 \text{ MT}$$

$$7,908 \text{ MT} @ 119 \text{ MT/day} \Rightarrow 66.54 \text{ DAYS}$$

\Rightarrow * 4 MONTHS

* ASSUMES 1 - 8 hr shift/day

* ASSUMES 100% Availability

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OU4 Vittrification and Potential Alternatives

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CALCULATIONS

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Using the 119 MT/day for silos 1 & 2

48,235 MT (orig. wt) @ 119 MT/day \Rightarrow 405 days

Assuming 80% avail. h. l. l. y \Rightarrow 506 days

\Rightarrow 2 years 260

N/ 2 8 hour sh. l. l. s \Rightarrow 253 days

\Rightarrow 1 year

N/ 3 8 hour sh. l. l. s \Rightarrow 168 days

\Rightarrow 8 months

A. 1-8 hour sh. l. l. s/day \Rightarrow 2 years \Rightarrow

B. 2-8 hour sh. l. l. s/day \Rightarrow 1 year \Rightarrow

C. 3-8 hour sh. l. l. s/day \Rightarrow 8 months

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VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1996

CALCULATIONS

IDENTIFICATION NUMBER: C5.4

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Silo 3

$$5000 \text{ CY} \times 574 \text{ / CY} \times 27 \text{ CF / CY} \times 1 \text{ MT / 2200 lbs} = 3559 \text{ MT}$$

$$3559 \text{ MT} @ 45\% \text{ W.U.} = 7908 \text{ Total Mass}$$

$$7908 @ 119 \text{ MT/day} = 66.4 \text{ days}$$

$$\textcircled{A} \text{ Plant Availability @ .80} \Rightarrow^* 83 \text{ days}$$

$$\Rightarrow^* 4 \text{ Months}$$

* ASSUMES 1-8 hour shift

$$\textcircled{B} \text{ W/ 2-8 hour shifts} \Rightarrow 42 \text{ days}$$

$$\Rightarrow 2 \text{ Months}$$

$$\textcircled{C} \text{ W/ 3-8 hour shifts} \Rightarrow 28 \text{ days}$$

$$\Rightarrow 1.5 \text{ Months}$$

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FORM: 30 DEC 1996

COST ESTIMATE - FIRST COST

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CASE A - 1 - 8 hour shift/day

Cost Item	Units	Unit Cost		Original Design		Recommended Design	
		\$/Unit	Source Code	Num of Units	Total \$	Num of Units	Total \$
Silo 3 Facility	Lot	4,225,000	1	1	4,225,000	0	0
Silo 3 Design	Lot	7,612,000	1	1	7,612,000	0	0
Silos 1 and 2 Facility	Lot	48,309,000	1	1	48,309,000	0	0
Silos 1 and 2 Design	Lot	14,273,000	1	1	14,273,000	0	0
Procure Modular Facility	Lot	31,401,000	7	0	0	1	31,401,000
Design Support/Spec.	Ea/Yr	220,000	1	0	0	10	2,200,000
Const. Mang.	Ea/Yr	125,000	7	0	0	14	1,750,000
Current Const. Mang.	Lot	9,604,000	1	1	9,604,000	0	0
Project Mang.	MO	312,500	1	40	12,500,000	28	8,750,000
Facility Operations	MO	754,430	1	40	30,177,000	28	21,124,000
D & D Silo 3 Facility	Lot	1	1	1	7,200,000	0	0
Totals					133,900,000		65,225,000

SOURCE CODE: 1 Project Cost Estimate
 2 CES Data Base
 3 CACES Data Base

4 Means Estimating Manual
 5 Richardson's (List job if applicable)
 6 Vendor Lit or Quote (list name / details)

7 Professional Experience
 8 Other Sources (specify)

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Project EM - Phase 2 Report
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VALUE ENGINEERING RECOMMENDATION

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COST ESTIMATE - FIRST COST

IDENTIFICATION NUMBER: C5.4

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CASE B - 2- 8 hour shifts/day

Cost Item	Units	Unit Cost		Original Design		Recommended Design	
		\$/Unit	Source Code	Num of Units	Total \$	Num of Units	Total \$
Silo 3 Facility	Lot	4,225,000	1	1	4,225,000	0	0
Silo 3 Design	Lot	7,612,000	1	1	7,612,000	0	0
Silos 1 and 2 Facility	Lot	48,309,000	1	1	48,309,000	0	0
Silos 1 and 2 Design	Lot	14,273,000	1	1	14,273,000	0	0
Procure Modular Facility	Lot	31,401,000	7	0	0	1	31,401,000
Design Support/Spec.	Ea/Yr	220,000	1	0	0	10	2,200,000
Const. Mang.	Ea/Yr	125,000	7	0	0	9	1,125,000
Current Const. Mang.	Lot	9,604,000	1	1	9,604,000	0	0
Project Mang.	MO	312,500	1	40	12,500,000	14	4,375,000
Facility Operations	MO	754,430	1	40	30,177,000	0	0
D&D Silo 3 Fac.	Lot	1	1	1	7,200,000	0	0
Proposed Fac. Oper.	MO	1,509,000	1	0	0	14	21,126,000
Totals					133,900,000		60,227,000

SOURCE CODE: 1 Project Cost Estimate
 2 CES Data Base
 3 CACES Data Base

4 Means Estimating Manual
 5 Richardson's (List job if applicable)
 6 Vendor Lit or Quote (list name / details)

7 Professional Experience
 8 Other Sources (specify)

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COST ESTIMATE - FIRST COST

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CASE C - 3 - 8 hour shifts/day

Cost Item	Units	Unit Cost		Original Design		Recommended Design	
		\$/Unit	Source Code	Num of Units	Total \$	Num of Units	Total \$
Silo 3 Facility	Lot	4,225,000	1	1	4,225,000	0	0
Silo 3 Design	Lot	7,612,000	1	1	7,612,000	0	0
Silos 1 and 2 Facility	Lot	48,309,000	1	1	48,309,000	0	0
Silos 1 and 2 Design	Lot	14,273,000	1	1	14,273,000	0	0
Procure Modular Facility	Lot	31,401,000	7	0	0	1	31,401,000
Design Support/Spec.	Ea/Yr	220,000	1	0	0	10	2,200,000
Const. Mang.	Ea/Yr	125,000	7	0	0	6.75	844,000
Current Const. Mang.	Lot	9,604,000	1	1	9,604,000	0	0
Project Mang.	MO	312,500	1	40	12,500,000	9.5	2,969,000
Facility Operations	MO	754,430	1	40	30,177,000	0	0
D&D Silo 3 Facility	Lot	1	1	1	7,200,000	0	0
Proposed Facility Oper.	MO	2,263,000	1	0	0	9.5	21,499,000
Totals					133,900,000		58,913,000

SOURCE CODE: 1 Project Cost Estimate 4 Means Estimating Manual 7 Professional Experience
2 CES Data Base 5 Richardson's (List job if applicable)
3 CACES Data Base 6 Vendor Lit or Quote (list name / details) 8 Other Sources (specify)

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ASSUMPTIONS

IDENTIFICATION NUMBER: C5.4

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1)	Modular facility operating requirement will be similar to current proposal for Silos 1 and 2. However, procuring a modular facility and services from an experienced stabilization contractor will result in substantial savings. Estimate equals 65% of current Silos 1 and 2, based on professional judgement ($0.65 \times \$48,309,000 = \$31,401,000$).
2)	Since design will be the responsibility of the contractor, only oversight will be required. Assume 10 engineers for one year duration.
3)	For construction management - Assume six project managers for operations duration plus four months.
4)	Project management costs based on current project duration.
5)	Silo 3 package/transport/dispose were deducted from operations monthly cost. Cost equals $(29,000,000 + 1,177,200) / 40 \text{ months} = 754,430 / \text{month}$.
6)	Unable to locate estimate for D & D of silo 3 stabilization facility. Assume 20% of total D & D. Leave current cost of D & D for silos 1 & 2 stabilization facility as allowance for D & D/demob of modular facility.

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Project EM - Phase 2 Report
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VALUE ENGINEERING RECOMMENDATION

FORM 20 DEC 1996

PROJECT: Critical Analysis of OU4 Vitrification and Potential Alternatives

Page 1 of 6

LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997

IDENTIFICATION NUMBER: D1.1

FUNCTION OF COMPONENT BEING CHANGED: Package Waste

DESCRIPTIVE TITLE OF RECOMMENDATION: Waste Packing/Shielding

ORIGINAL DESIGN:

Alternative 3

Silo 3 - Place stabilized waste in white metal box

Silos 1 & 2 - Place stabilized waste in SEG concrete boxes

RECOMMENDED CHANGE:

Silos 1 and 2 waste treatment (Alternative 3), use white metal boxes with internal shielding as required to meet DOT and NTS criteria. A container optimization study must be performed, in concert with a stabilization mix formulation to arrive at the optimal cost/safety path forward. The attached chart indicates additional savings of up to \$40 million is possible.

SUMMARY OF COST ANALYSIS			
	First Cost	O & M Costs (Present Worth)	Total LC Cost (Present Worth)
ORIGINAL DESIGN	197,540,000	0	197,540,000
RECOMMENDED DESIGN	81,542,000	0	81,542,000
ESTIMATED SAVINGS OR (COST)	115,998,000	0	115,998,000

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Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: D1.1

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ADVANTAGES:

- Reduces the number of containers.
- Reduces the cost per container.
- Reduces the number of shipments.
- Reduces the disposal volume.

DISADVANTAGES:

- Additional handling to place shielding in containers.

JUSTIFICATION:

The current plan produces a waste package with an estimated 15 mrem/h at the exterior of the container. DOT accepts 200 mrem/h. NTS will accept 200 mrem/h, but prefers containers to have a maximum of 100 mrem/h. Decreasing the shielding while still maintaining an exterior dose of <100 mrem/h will increase the payload capacity of each shipment, thus decreasing the number of containers and shipments required. Based on Alternative 3, the number of containers is reduced from 20,700 SEG boxes to 19,364 white metal boxes lined with 4-in. foam. The number of shipments is reduced from 10,350 to 4,841.

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OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1996

CALCULATIONS

IDENTIFICATION NUMBER: D1.1

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Assume 1.73 yd³ of stabilized Silo 1 and 2 material is shipped in a shielded white metal box.

Use Alternative 3 basis of 33,500 yd³ of treated waste.

$$33,500 \text{ yd}^3 = 19,364 \text{ boxes @ 4 boxes/truck}$$

$$1.73 \text{ yd}^3/\text{box}$$

$$\Rightarrow 4,841 \text{ shipments}$$

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Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

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% Waste	Treated Volume Yd ³	# of Containers	Cost per Container	# of Trips	Container Cost	Transportation Cost	Disposal Cost	Total Cost	mrem/yr			% Waste Loading	WMU	SEG
			\$		\$	\$	\$	\$	contact (1cm)	1 m	2m			
20	33500	10364	\$800	4841	\$15,401,329	\$17,350,289	\$48,700,867	\$81,542,486	95.7	21.51	7.895	20	\$81,542,486	\$107,950,774
30	27313	12009	\$800	3227	\$10,327,553	\$11,566,859	\$32,467,245	\$54,361,657	143.6	32.27	11.84	30	\$54,361,657	\$131,967,183
40	16750	9082	\$800	2421	\$7,745,665	\$8,875,145	\$24,350,434	\$40,771,243	191.4	43.03	15.79	40	\$40,771,243	\$98,975,387
50	13400	7746	\$800	1938	\$6,196,532	\$6,940,116	\$19,480,347	\$32,616,804	239.3	53.78	10.74	50	\$32,616,804	\$70,180,310
20	33500	20743	\$4,746	10372	\$98,446,440	\$37,171,517	\$62,332,617	\$197,950,774	15.12	4.609	1.773			
30	27313	13829	\$4,746	6914	\$65,030,860	\$24,781,011	\$41,555,212	\$131,987,183	22.68	6.014	2.659			
40	16750	10372	\$4,746	5186	\$49,223,220	\$18,585,759	\$31,166,409	\$98,975,387	29.89	9.111	3.504			
50	13400	8297	\$4,746	4149	\$39,378,576	\$14,868,607	\$24,033,127	\$78,180,310	37.81	11.52	4.432			

Packaging, Shipping & Disposal Cost



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OU4 Vitrification and Potential Alternatives

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Container	Distance (cm)		
	1	100	200
WMB 1/2 high cement, 20% Dry wt.	151.5	95.7	21.51
WMB 1/2 high cement, 30% Dry wt.			
WMB 1/2 high cement, 40% Dry wt.			
WMB 1/2 high cement, 50% Dry wt.			
WMB Full high cement, 20% Dry wt., w 4" Foam	95.7	21.51	7.895
WMB Full high cement, 30% Dry wt., w 4" Foam	143.6	32.27	11.84
WMB Full high cement, 40% Dry wt., w 4" Foam	191.4	43.03	15.79
WMB Full high cement, 50% Dry wt., w 4" Foam	239.3	53.78	19.74
SEG Box, 20% Dry wt.	17.87	6.2	2.384
SEG Box, 30% Dry wt.	26.8	9.3	3.576
SEG Box, 40% Dry wt.	35.74	12.4	4.787
SEG Box, 50% Dry wt.	44.67	15.5	5.96
SEG Box, 20% Dry wt., w 4" Foam	12.54	3.384	1.298
SEG Box, 30% Dry wt., w 4" Foam	18.81	5.076	1.984
SEG Box, 40% Dry wt., w 4" Foam	24.79	6.689	2.567
SEG Box, 50% Dry wt., w 4" Foam	31.35	8.46	3.246
SEG Box, 20% Dry wt., w 2" Foam	15.12	4.609	1.773
SEG Box, 30% Dry wt., w 2" Foam	22.68	6.914	2.659
SEG Box, 40% Dry wt., w 2" Foam	29.89	9.111	3.504
SEG Box, 50% Dry wt., w 2" Foam	37.81	11.52	4.432
WMB Full high cement, Silo 3, 45% Waste Load	3.519	0.7246	0.2589
SEG Box, gems, 20% additives	60.19	21.09	8.069
SEG Box, gems, 30% additives	52.67	18.45	7.06

Source - Doug Daniels, FERMCO

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Project EM - Phase 2 Report
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OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

FORM: 30 DEC 1996

COST ESTIMATE - FIRST COST

IDENTIFICATION NUMBER: D1.1

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Cost Item	Units	Unit Cost		Original Design		Recommended Design	
		\$/Unit	Source Code	Num. of Units	Total \$	Num. of Units	Total \$
Current Box	EA	4,746	1	20,700	98,242,000	0	0
Shipping	EA	3,584	1	10,350	37,094,000	4,841	17,350,000
Current Dispose	EA	3,005	1	20,700	62,204,000	0	0
Proposed Box	EA	800	1	0	0	19,364	15,491,000
Proposed Disposal	EA	2,515	1	0	0	19,364	48,700,000
Totals					197,540,000		81,542,000
Assumption:							
Proposed disposal cost is based on exterior volume of container							
(\$3,005/box) / (4.9 cy/box) x (4.1 cy/box) = \$2,515/box							

SOURCE CODE: 1 Project Cost Estimate
 2 CES Data Base
 3 CACES Data Base

4 Means Estimating Manual
 5 Richardson's
 6 Vendor Lit or Quote (list name / details)

7 Professional Experience
 (List job if applicable)
 8 Other Sources (specify)

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Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

FORM 20 DEC 1996

PROJECT: Cost Analysis of OU4 Vitrification and Potential Alternatives

Page 1 of 5

LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997

IDENTIFICATION NUMBER: D2.1

FUNCTION OF COMPONENT BEING CHANGED: Enclose Waste

DESCRIPTIVE TITLE OF RECOMMENDATION: Stabilization/Solidification

ORIGINAL DESIGN:

Purchase SEG containers for packaging of Silos 1 and 2 vitrified waste gems.

RECOMMENDED CHANGE:

Use white metal type box with insert in place of SEG containers. Fill 6 in. space between box and insert with stabilized Silo 3 waste. An additional consideration would be to fabricate metal boxes using DOE owned contaminated scrap metal. The fabricated metal box must be substantial enough to accept the load. The internal space (for gems) should be the same volume as in the SEG container.

SUMMARY OF COST ANALYSIS

	First Cost	O & M Costs (Present Worth)	Total LC Cost (Present Worth)
ORIGINAL DESIGN	27,324,000	0	27,324,000
RECOMMENDED DESIGN	8,842,000	0	8,842,000
ESTIMATED SAVINGS OR (COST)	18,382,000	0	18,382,000

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Project EM - Phase 2 Report
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OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: D2.1

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ADVANTAGES:

- Reduces the number of Silos 1 and 2 waste boxes required.
- Eliminates the need for containers for Silo 3 waste.
- Effectively uses the Silo 3 wastes.
- Reduces the generation of additional contaminated waste.
- Could replace the use of clean metal with contaminated scrap metal.
- Maximizes waste minimization.

DISADVANTAGES:

- Need to purchase or fabricate metal boxes.
- Need to design waste box inserts.
- Need to form and place floor, walls and lid using Silo 3 waste.
- Needs storage location for fabricated boxes.
- May need to provide radiation and breathing air protection for workers.
- Need to design white metal boxes to meet transportation requirements.

JUSTIFICATION:

The baseline Silos 1 and 2 treated waste boxes are SEG boxes. Each box is new, and consists of a concrete cube having 6 in. thick walls. At the same time silo 3 wastes are being made into concrete and placed in new white metal boxes. This proposal uses treated waste to fabricate boxes for vitrified waste. It also reduces waste generation.

An additional consideration is to fabricate the metal boxes from DOE contaminated scrap metal. At a 45% waste loading, 9,200 gem boxes are required. Consider making the remaining 3,820 ($9,200 - 5,380 = 3,820$) gem boxes required onsite using clean concrete. That is, once the gem box assembly line is operating, continue its operation and fabricate all boxes onsite.

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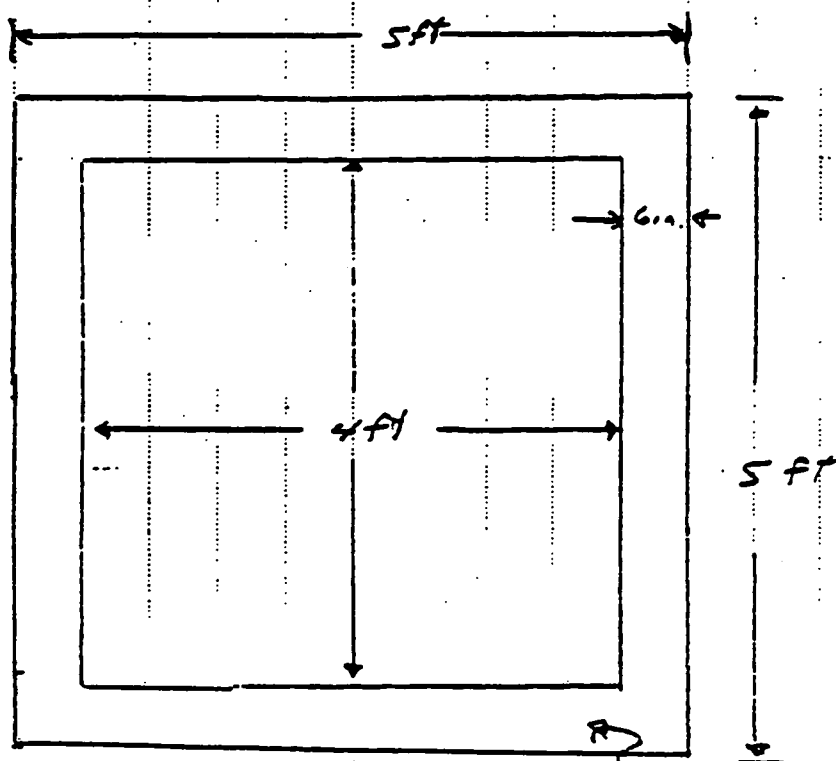
VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1996

SKETCH OF ORIGINAL DESIGN

IDENTIFICATION NUMBER: D2.1

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Floor : 5 ft x 5 ft x 0.5 ft

Walls : 4 ft x 4.5 ft x 0.5 ft - 4 walls

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VALUE ENGINEERING RECOMMENDATION

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CALCULATIONS

IDENTIFICATION NUMBER: D2.1

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Internal volume of gem containers - $2.37 \text{ yd}^3 = 64 \text{ ft}^3 = 4 \text{ ft} \times 4 \text{ ft} \times 4 \text{ ft}$
External volume of gem container (6 in. floor, walls and lid)
$4.2 \text{ yd}^3 = 112.5 \text{ ft}^3: 5 \text{ ft} \times 5 \text{ ft} \times 4.5 \text{ ft}$
Concrete used:
Lid: $5 \times 5 \times 0.5 = 12.5 \text{ ft}^3$
Floor: $5 \times 5 \times 0.5 = 12.5 \text{ ft}^3$
Walls: $4 \times 4 \times 4.5 \times 0.5 = 36 \text{ ft}^3$
$67 \text{ ft}^3 = 2.26 \text{ yd}^3$
Assume $\frac{1}{2}$ of waste box concrete is Silo 3 waste, $\frac{1}{2}$ is new concrete.
Gem boxes fabricated: $2694 \times 2.26 \text{ yd}^3/\text{box} = 6088 \text{ yd}^3/\text{concrete}$
If $\frac{1}{2}$ of the concrete is Silo 3 waste, $2 \times 2690 = 5380$. 5380 boxes can be fabricated to use all of the Silo 3 waste.
• Fabricate 5380 gem boxes using 6088 yd^3 of Silo 3 waste and 6088 yd^3 of concrete.
• Save 5380 SEG boxes.
• Silo 3 waste is 6088 yd^3 so none left.
• Save 2160 white metal boxes.
• Fabricate 5380 white metal boxes.

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Project EM - Phase 2 Report
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OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

FORM: 30 DEC 1996

COST ESTIMATE - FIRST COST

IDENTIFICATION NUMBER: D2.1

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Cost Item	Units	Unit Cost		Original Design		Recommended Design	
		\$/Unit	Source Code	Num of Units	Total \$	Num of Units	Total \$
Silo 3 Containers	EA	800	1	2,160	1,728,000	0	
Silo 3 Transport	EA	3,200	1	540	1,728,000	0	
Silo 3 Disposal	CS	241,920	1	20	4,838,000	0	
Gem Containers	EA	3,500	1	5,380	18,830,000	0	
Fab. Metal Box With Inserts	EA	1800	7	0	0	5,380	8,070,000
Additional Concrete	CY	112	1	0	0	6,088	682,000
Additional Labor	HR	31.4	1	0	0	2,880	90,000
Total					27,324,000		8,842,000
Assumption: Cost for fabricated metal boxes will equal cost of standard metal box.							
For pouring operations complexity - 3 additional operators at 8 hours/day, 5							
days/week for six months duration.							

SOURCE CODE: 1 Project Cost Estimate 4 Means Estimating Manual 7 Professional Experience
2 CES Data Base 5 Richardson's (List job if applicable)
3 CACES Data Base 6 Vendor Lit or Quote (list name / details) 8 Other Sources (specify)

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Project EM - Phase 2 Report
Fernald Environmental Management Project
OU4 Vitrification and Potential Alternatives

VALUE ENGINEERING RECOMMENDATION

FORM 20 DEC 1996

PROJECT: Critical Analysis of OU4 Vitrification and Potential Alternatives

Page 1 of 5

LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997

IDENTIFICATION NUMBER: D4.1

FUNCTION OF COMPONENT BEING CHANGED: Waste Disposal

DESCRIPTIVE TITLE OF RECOMMENDATION: Commercial Disposal

ORIGINAL DESIGN:

Dispose of cemented (stabilized) Silo 3 waste in white metal boxes at Nevada Test Site.
 Transportation is by truck.

RECOMMENDED CHANGE:

Dispose of cemented (stabilized) silo 3 waste in white metal boxes at Envirocare of Utah, Inc.
 (Clive UT) facility. Transportation is by truck (or rail).

SUMMARY OF COST ANALYSIS			
	First Cost	O & M Costs (Present Worth)	Total LC Cost (Present Worth)
ORIGINAL DESIGN	5,419,008	1,935,360	7,354,368
RECOMMENDED DESIGN	1,801,068	1,451,520	3,252,588
ESTIMATED SAVINGS OR (COST)	3,617,940	483,840	4,101,780

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VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: D4.1

Page 2 of 5

ADVANTAGES:

- Reduced cost if you can meet the Waste Acceptance Criteria.
- Accessible by truck or rail.
- Possible reuse of shipping containers.
- Additional savings via rail.

DISADVANTAGES:

- Lower (more stringent) waste acceptance criteria.
- Possible change in waste classification required.
- Large quantities of cement/stabilizer may need to be added.
- Possible increase in liability and regulatory requirements.
- Modifications to the Envirocare waste permit would be required.

JUSTIFICATION:

Envirocare of Utah, Inc. is a commercial LLRW disposal facility that charges less than the current disposal facility - Nevada Test Site (NTS). Silo 3 material may be able to meet the waste acceptance criteria once the stabilizer is added. This option probably could not be used if silo 3 waste is vitrified. It appears that approximately 25 times the original volume of waste must be added at Envirocare to bring the concentration of thorium-230 within waste acceptance criteria for Envirocare. This will require amending their existing permit.

Additional savings may be realized from the return and reuse of the containers. NTS does not return containers. If the waste is shipped using railcars even more savings will be realized. NTS does not have a rail spur. Problems may be found in meeting the waste acceptance criteria for Envirocare, though. The waste may need to lose its exemption from being a hazardous waste. This is likely to increase administration costs (manifesting, changing designation, etc.), increase liability, and risk additional regulatory requirements.

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VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1996

SKETCH OF ORIGINAL DESIGN

IDENTIFICATION NUMBER: D4.1

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WASTE
↓
STABILIZATION
OR
VITRIFICATION
↓
TRANSFER BY
TRUCK
↓
DISPOSAL AT
NEVADA TEST SITE
(NTS)

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FORM: 20 DEC 1996

SKETCH OF ORIGINAL DESIGN

IDENTIFICATION NUMBER: D4.1

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WASTE
↓
STABILIZATION
(CEMENTATION)
↓
TRANSFER BY
TRUCK OR RAIL
↓
DISPOSAL AT
ENVIROCARE OF UTAH, INC.
(CLIVE, UT)

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CALCULATIONS

IDENTIFICATION NUMBER: D4.1

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2160 White metal boxes	Ext. Volume of Box = 4.1 cy
540 Waste shipments	Int. Volume of Box - 3.1 cy
4 Boxes/Waste Shipment	
<u>NTS (charges by external volume of container)</u>	
Transportation: 540 WS x \$3200/WS = \$1,728,000	
Disposal: 4.1 cy/box x 2,160 boxes x 27 cf/cy = 241,920 cf	
241,920 cf x \$20/cf = \$4,838,400	
T & D = \$1,728,000 + \$4,838,400 = \$6,566,400	
Target Estimate= Base Estimate + Risk Budget	
= \$6,566,400 + 12%	
= \$7,354,368	
<u>Envirocare (Charges by internal volume of container)</u>	
T: 540 WS x \$2400/WS = \$1,296,000	
D: 2160 boxes x 3.11 cy x \$239/cy = \$1,608,096	
T & D: = \$2,904,096	
Target Estimate = \$3,252,588	
All quantities used were from the original estimate or backup except:	
1) Envirocare disposal cost (Reference: US Army Corps of Engineers disposal contract with Envirocare of UT, Inc.)	
2) Envirocare transportation waste shipment cost. (Reference: "Screening Evaluation of Silo 3 Alternatives")	

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PROJECT: Critical Analysis of OU4 Vitrification and Potential Alternatives

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LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997

IDENTIFICATION NUMBER: E1.1

FUNCTION OF COMPONENT BEING CHANGED: Treat Waste

DESCRIPTIVE TITLE OF RECOMMENDATION: Innovative Procurement

ORIGINAL DESIGN:

Provide large, new vitrification/stabilization facility for treatment of OU4 silos waste. Facility(s) to be designed, constructed, operated by FDF or FDF subcontractors.

RECOMMENDED CHANGE:

Evaluate and, where practical, implement alternative and innovative procurement strategies. For example, turnkey subcontracting or some form of privatization; preparation and use of a performance specification instead of a design specification; contract options to include treatment of Silos 1 and 2 waste (if performance on Silo 3 waste is acceptable) and D & D of the silos. Also consider incentivized contracting that links payment (profit) to a) meeting and exceeding cost and schedule milestone; b) zero accidents; c) zero radiological incidents; d) percentage of product meeting WAC; e) amount of product accepted/rejected by the disposal sites; and f) number of transportation incidents/accidents. An incentivized contract could also include sharing any savings resulting from a subcontractor's cost saving ideas.

The contract should also outline a program that minimizes DOE/FDF direct involvement. Instead, these entities would primarily overview, audit, and validate subcontractor performance. The subcontract should also include cradle-to-grave responsibility for the subcontractor, that is, from waste retrieval to delivery of the treated waste to the disposal site. Subcontractor progress payments must be based on measurable progress (e.g., silo waste disposed, product formulated).

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VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: E1.1

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ADVANTAGES:

- Maximize the involvement of private industry and their expertise.
- Maximize the leverage gained from competition.
- Maximize the motivation of profit with "for profit" organizations.
- Extend the "life" and increase the responsibility of a satisfactorily performing contractor.
- Concentrate responsibility under a single subcontract and subcontractor.
- Maximize the value from current/ongoing FDF/DOE/Fernald site experience lessons learned.
- Minimize the number of subcontractors.

DISADVANTAGES:

- Requires careful thought and preparation.
- Demands innovative thinking and approaches.
- May require relief from FAR/DEAR requirements.
- Requires preparation of objective/quantitative measurable, reportable, and easily understood performance indicators.
- Requires careful monitoring and oversight to validate reported performance.

JUSTIFICATION:

Implementing this proposal will facilitate identification of the most experienced contractors and use the competitive edge to ensure the lowest life cycle cost for executing the remediation action.

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PROJECT: Critical Analysis of OU4 Vitrification and Potential Alternatives

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LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997

IDENTIFICATION NUMBER: E1.2

FUNCTION OF COMPONENT BEING CHANGED: Treat Waste

DESCRIPTIVE TITLE OF RECOMMENDATION: Independent Reviews of RFP

ORIGINAL DESIGN:

Provide large, new vitrification/stabilization facility for treatment of OU4 silos waste. Facility(s) to be designed, constructed, operated by FDF or FDF subcontractor.

RECOMMENDED CHANGE:

Award a contract based on turnkey subcontracting or some form of privatization; include incentives as well as options for additional work. The subcontract would be based on a performance specification advertized and awarded through an RFP and an evaluation/selection board. RFP reviewers should include independent, outside experts. The subcontractor selection board should include outside experts. The proposed RFP will be somewhat unique, and the experience of others who have prepared and/or reviewed similar documents should prove valuable. Selection of the subcontractor is also somewhat different in that weighted selection criteria will be used and not simply price. Selection will be based on board reviews and analyses of RFP responses, as well as in-depth interviews of prospective bidders.

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VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: E1.2

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ADVANTAGES:

- Obtain input from personnel experienced in the described process.
- Maximize lessons learned from the experience of others.
- Maximize the input from experts in reviewing the draft RFP for omissions, errors, and contradictions.
- Obtain experienced/expert input in developing evaluation criteria and properly weighting and evaluating those criteria.
- Obtain the support of personnel experienced in visiting, interviewing, and evaluating potential subcontractors.

DISADVANTAGES:

- Requires time and effort to: identify and obtain the services of experienced/expert personnel; prepare and issue an acceptable RFP; and identify criteria and prepare proper and defensible weighting factors.
- Requires time and effort to prepare and issue an acceptable RFP.
- Requires time and effort to identify criteria and prepare proper and defensible weighting criteria.

JUSTIFICATION:

If turnkey/privatization subcontracting is to be successfully pursued, significant care and attention will be required to prepare and issue an RFP, prepare complete and properly weighted evaluation criteria, and complete meaningful subcontractor interviews and evaluations. The success of the proposed approach is totally dependent upon the RFP and evaluation of responses to the RFP. For example, the RFP must be clear and concise, yet complete and understandable. Evaluation criteria must be clear, complete, and properly weighted. In addition, and perhaps most importantly, all activities must be defensible.

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VALUE ENGINEERING RECOMMENDATION

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PROJECT: Cost Analysis of OU4 Vitrification and Potential Alternatives

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LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997

IDENTIFICATION NUMBER: E2.1

FUNCTION OF COMPONENT BEING CHANGED: Contracting Philosophy

DESCRIPTIVE TITLE OF RECOMMENDATION: Improve Contracting

ORIGINAL DESIGN:

Solicit RFP for Silo 3 remediation independently of Silos 1 and 2 remediation strategy. Award contracts separately; construct two treatment facilities; and operate them at two separate times.

RECOMMENDED CHANGE:

Incorporate options in the Silo 3 contract for remediation for Silos 1 and 2 in RFP if solidification is the chosen technology for Silos 1 and 2. If the contractor performs Silo 3 remediation to meet/exceed requirements then exercise options for Silos 1 and 2.

NOT COSTED. SEE RECOMMENDATION D5.4.

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IDENTIFICATION NUMBER: E2.1

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ADVANTAGES:

- Allows for easy transition to remediate Silos 1 and 2.
- Eliminate the oversight of two different contracts.
- May eliminate the orientation and the demobilization/mobilization of a new contractor, and orientating and training a new workforce.
- Were the options exercised, this would eliminate possible congestion within a small area.
- May allow the silos to be treated in parallel rather than sequentially.
- Would reduce overall treatment schedule by 2 years.
- Would eliminate the design, construction, operation, and D & D of a second treatment facility.

DISADVANTAGES:

- Would require the existing record of decision (ROD) to be amended to permit solidification as an acceptable treatment method.

JUSTIFICATION:

Currently the site is preparing a request for proposals to solidify Silo 3 waste. This is being pursued independently of the Silo 1 and 2 remediation effort. This is consistent with the existing ROD that indicates that vitrification is the proper treatment for the contents of Silos 1 and 2. When the ROD is amended to allow solidification of Silos 1 and 2 wastes, the successful bidder for Silo 3 remediation could be utilized for Silos 1 and 2 remediation through an option to the original contract. That is, if the stabilization facility is operating well and the treated product consistently meets requirement, permit the subcontractor to process the Silos 1 and 2 waste.

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LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997

IDENTIFICATION NUMBER: E2.3

FUNCTION OF COMPONENT BEING CHANGED: Design/Construct Plants

DESCRIPTIVE TITLE OF RECOMMENDATION: Stabilization/Solidification

ORIGINAL DESIGN:

Design/construct two cementitious batch plants of differing capacity (3 cy/hour & 4 cy/hour, see calculations) to treat Silos 1, 2, and 3 waste. These plants are scheduled to operate sequentially, 8 hours/day, 5 days/week for a total of 3 years.

RECOMMENDED CHANGE:

Procure batch plants (design and erection) from manufacturer (3.0 cy/hour & 4.9 cy/hour).
Operate plants 24 hours/day for approximately 8 months.

* NOT COSTED - SEE RECOMMENDATION E2.1

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VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: E2.3

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ADVANTAGES:

- Procuring design and erection services from a manufacturer whose primary business is providing batch plant services eliminates redesign of existing technologies.
- Operating a plant 24 hours/day reduces total life-cycle costs substantially.
- Eliminates potential of having another contractor supply the second plant.
- Treats waste in a much shorter period of time.
- Operates the facility in a more normal mode.

DISADVANTAGES:

- Duplicate operating crews.
- Duplicate waste feed and additive feed system.
- Duplicate utilities.
- Requires modifications to control radon and ensure worker safety from radiological exposure.

JUSTIFICATION:

Utilizing solidification through cementation as a means for stabilizing the waste requires relatively minor modifications to a proven technology compared to the complex system for vitrification. Operation of a batch plant type facility 24 hours a day is not uncommon in the industry. It completes waste processing much more rapidly and accelerates the completion of OU4.

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LOCATION: Fernald, Hamilton County, Ohio

STUDY DATE: March 10-21, 1997.

IDENTIFICATION NUMBER: E2.4

FUNCTION OF COMPONENT BEING CHANGED: Minimize Requirements

DESCRIPTIVE TITLE OF RECOMMENDATION: DOE Orders and Standards

ORIGINAL DESIGN:

Require full compliance with all DOE orders and standards regardless of the contracting method selected. That is, do not allow the application of commercial standards.

RECOMMENDED CHANGE:

Relieve the requirement that the subcontractor comply with all DOE orders, standards and requirements. Instead, allow the contractor to meet commercial standards, as long as the product (treated waste) meets WAC. DOE orders and standards are mostly self-generated and self-imposed. In addition, most are not required by law. They are, however, almost without exception, very detailed and require significant staff to interpret, apply, report, monitor, and enforce. Typical examples include 5700.6C (Quality Assurance); 6430.1A (Design criteria); 4700.1 (Project Management); ORR; startup; PTS reporting; SAR; USQ; and records management.

Although requiring significant effort and resources, in general, these documents do very little if anything to increase safety or improve the product (treated waste).

NOT COSTED - SEE RECOMMENDATION E2.1

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IDENTIFICATION NUMBER: E2.4

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ADVANTAGES:

- Eliminate unnecessary requirements.
- Simplify identification of and compliance with necessary requirements.
- Reduces cost.
- Reduces staff.
- Reduces oversight and reporting requirements.

DISADVANTAGES:

- Requires a dedicated commitment to effect implementation.
- Requires formal request and approval by DOE-HQ.

JUSTIFICATION:

By permitting turnkey subcontractors to meet commercial standards, significant savings can be realized.

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Appendix F

Design Suggestions

Several design suggestions are presented in this section. Design suggestions are ideas that were, in the opinion of the Project EM team, good ideas, but nevertheless not selected for development and presentation as a formal proposal. Design Suggestions, by definition, have not been developed (proven) through team development and write ups. The team presents these ideas for further consideration by the owner and designer and if accepted, subsequent development by the designer. Design Suggestions, G1, G3, and so forth were developed during the brainstorming part of the VE study.

G1 - FDF, EPA, State EPA, DOE Task Force

The VE team found that a major uncertainty involved in the silo waste treatment decision is the impact of this decision upon the approved ROD. Opinions concerning the impact range from very minor to major.

Because the importance this issue has upon a path-forward determination, the VE team recommends that FDF, EPA, the state EPA and DOE form a task force to expedite the ROD process. This task force could, knowing the two possible paths forward, identify the ROD/permit path forward for each alternative. The path forward would include the type of change required, the process involved, the approvals involved, the steps required and the estimated time required. Once a treatment decision is made, then necessary activities can immediately begin. This approach would 1) identify the necessary steps; 2) identify the activities and approvals required to accomplish each step; 3) pre-assign actions and responsibilities; and 4) encourage the team to resolve any problems. Such an approach should increase understanding and cooperation and decrease the time and effort required to implement any change to the ROD.

G3 - Rail Shipments

Consider the use of unit trains for any rail shipments of waste. Unit trains may save as much as 6% of the cost for standard rail transport. Rail shipments should be coordinated with the waste shipments from other OUs on-site to better justify unit trains. Any inter-modal (rail/truck) shipments should be coordinated with waste shipments from other OUs.

Transportation issues related to waste disposition should be planned using the on-site staff that is highly knowledgeable in this area. They can help determine the most efficient strategy (in cost and schedule) for transporting the waste.

The use of inter-modal transportation of wastes to NTS may produce modest cost benefits. However, it is likely to be a safer transportation method. Transportation via rail will reduce costs for waste shipments going to Envirocare of Utah, Inc. Again, transportation by way of rail is safer than transportation via truck.

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G6 - Evaluate Changes to Labor Agreement

The existing labor agreement between FDF and the Fernald site crafts (labor unions) requires that FDF personnel perform all on-site labor activities that are normally within their area of responsibility regardless of the organization (FDF, vendor, subcontractor) responsible for the overall task. As a result, some of the potential cost benefits associated with subcontracting cannot be fully realized. In addition, the agreement complicates work efforts because of the split it imposes between authority and responsibility.

The VE team recommends that when future labor agreements are negotiated, considerable effort be made to maximize the flexibility of a subcontractor to obtain labor forces to accomplish his subcontracted scope of work.

G7 - VE Contract Clause

For several years the concept of VE has been recognized and fully embraced by DOE. The DOE has also recommended the inclusion of a VE clause in all subcontract documents/agreements.

The VE team suggests that FDF ensure that the DOE VE recommendation is implemented by incorporating the DOE's VE clause in all subcontract documents. The team further recommends that during the subcontract period of execution interim checks and reports be required to ensure that full value is being obtained from the VE concept and application.

G8 - Robotics

The silos waste retrieval and heel removal robot (Houdini) is of serious concern to the Project EM team. Historically, experience with similar units has been problematic. Problems have included unexpected and frequent failures, inability to perform intended tasks, unanticipated operating conditions, longer times than anticipated to perform intended tasks and inadequately trained operators.

At Fernald, Houdini is expected to:

- Enter and exit all three silos through a man way while "folded" into a retracted position.
- Extend and retract while either hanging from the control tether or while positioned on top of the silos residue.
- Operate in both Silos 1 and 2 slurries and the Silo 3 fine dust.
- Move (manage) dense materials.
- Provide round-the-clock support.
- Remove foreign objects from the Silo waste.

Suggestions to increase Houdini's effectiveness and operating efficiency include:

- Extensive operator training for at least five operators. Whenever Houdini is needed for support, round-the-clock operation will probably be needed. Therefore at least five operators will be needed. Because of the stress and tension associated with remote operations, five hours is a long "shift" for a remote operator.

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- Four well-trained maintenance personnel.
- An ample supply of spare parts, especially cameras, lights, switches and motors.
- A thorough incident/accident evaluation to study failures, operating situations and maintenance requirements and to identify recovery actions.
- Mock-up testing and Houdini operation in both dry dust and slurries. Tests should be conducted without the operator having visual contact with Houdini. Testing should also include simulated incidents, (for example, Houdini rolling onto its "back," recovery without lights, cameras, or power.)
- Finally, a simple, robot backup/recovery should be devised. For example, mirrors, lights and cameras on rods and snare tools.

G10 - Improve Communications

An almost uniform VE team observation of the FDF activities is the limited amount of communication among the managers of the several OUs. The project teams appear to have little knowledge of or involvement in the activities of any team other than the one to which they are assigned. The reason this observation is mentioned is because inadequate communication leads to several potential problems:

- Duplication of effort. Unless each team is aware of the activities of the others, the different teams could expend effort in performing similar studies. An additional and greater risk is that similar studies by different OUs may yield different results.
- The FDF image. Lack of communications could lead other organizations (DOE, stakeholders) to conclude the FDF management system is lacking and the FDF managers are not in control.
- Conflicting/opposing efforts. The possibility exists that the OUs could implement totally opposite actions and activities. That is, the actions could be at cross-purposes.
- Overall site integration. Lack of communication could lead to several OUs expecting to use limited site support (utilities, for example) at the same time. In such an event, some activity will not receive needed support.
- Lessons learned. Lessons learned by others are valuable sources of information. Inadequate communications could lead to inadequate use of lessons learned by others.

G11 - Independent Baseline Cost Estimate

The Project EM team recommends that an independent baseline cost estimate be prepared for the OU4 remediation concept.

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Appendix G

Value Engineering Cost Charts

Appendix G documents the summary cost information used during the study. Also included are several charts depicting major categories of cost for Alternatives 2 and 3.

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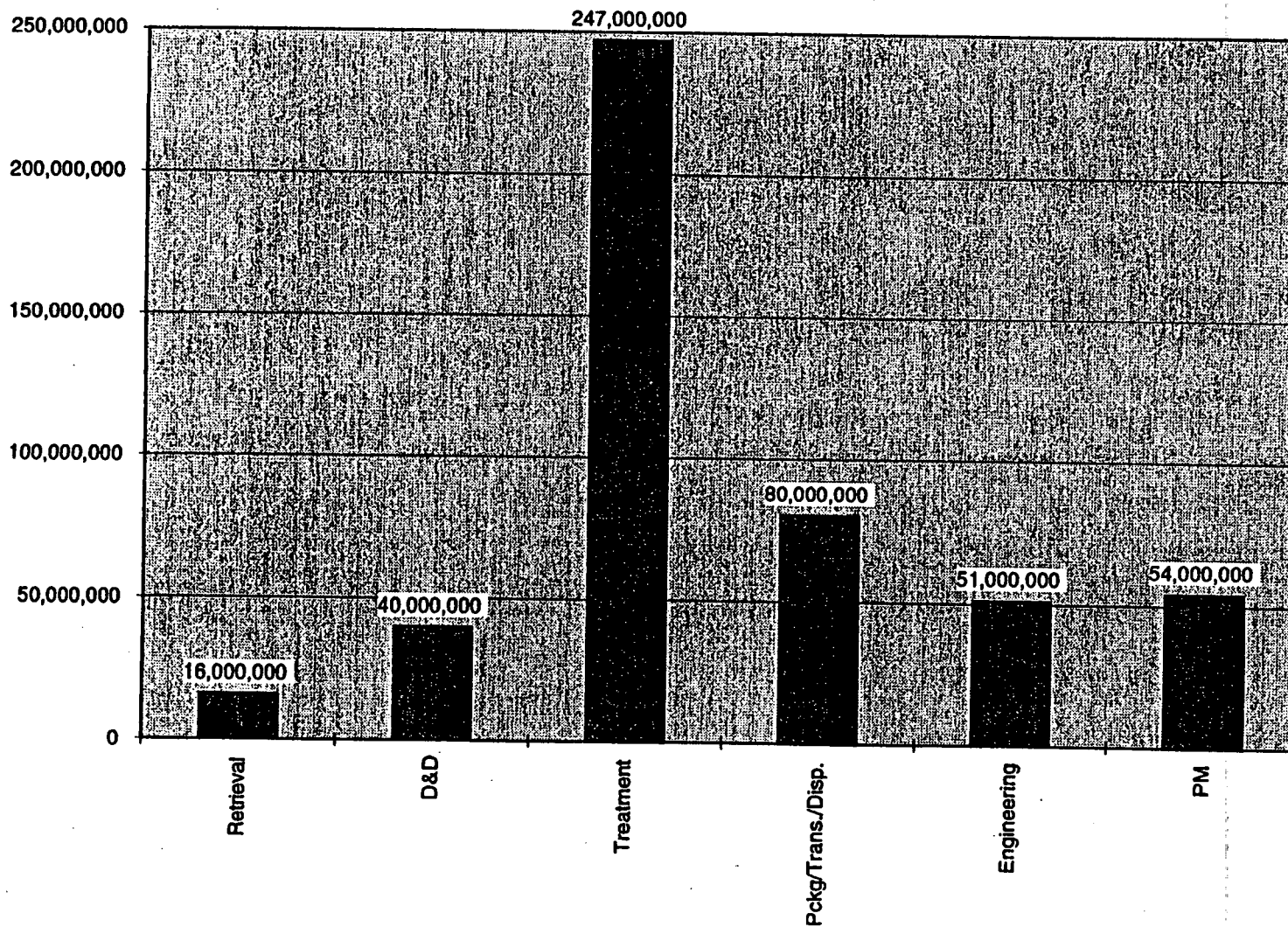
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Basis of Charts

Category Description	Alternative 2 (\$000,000)	Alternative 3 (\$000,000)
Vitrification Pilot Plant Cost	12	9
Silo #3 Stabilization Cost	25	25
Final Remediation Engineering Cost	51	20
Final Remediation Construction Cost	135	68
Final Remediation Operation Cost	75	29
Waste Pkg/Shipping/Disposal Cost	80	198
D&D/Soils Remediation Cost	40	36
Project Management Cost	54	45
Waste Retrieval Cost	16	12
Total Analyzed Cost	\$ 488	\$ 442

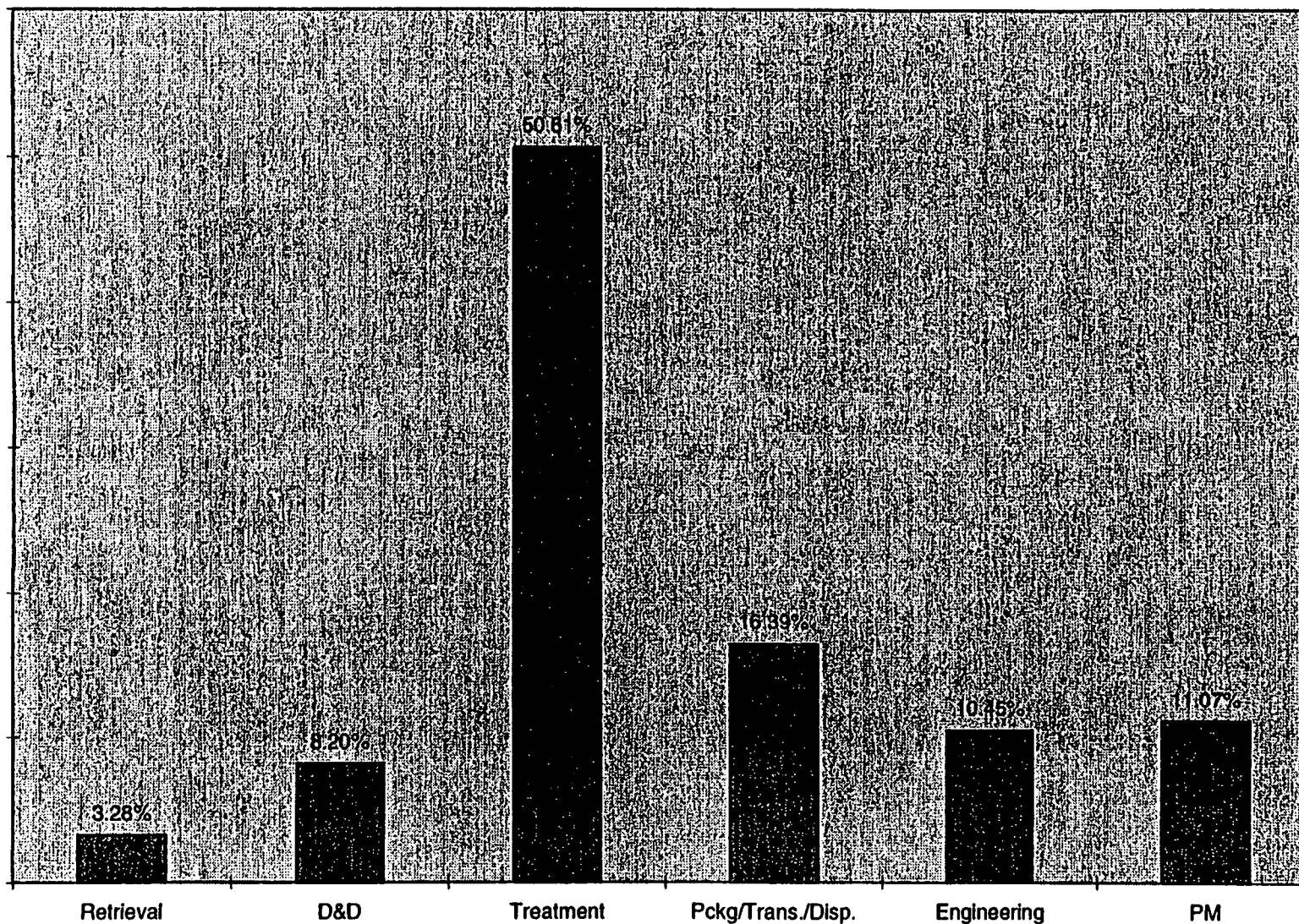
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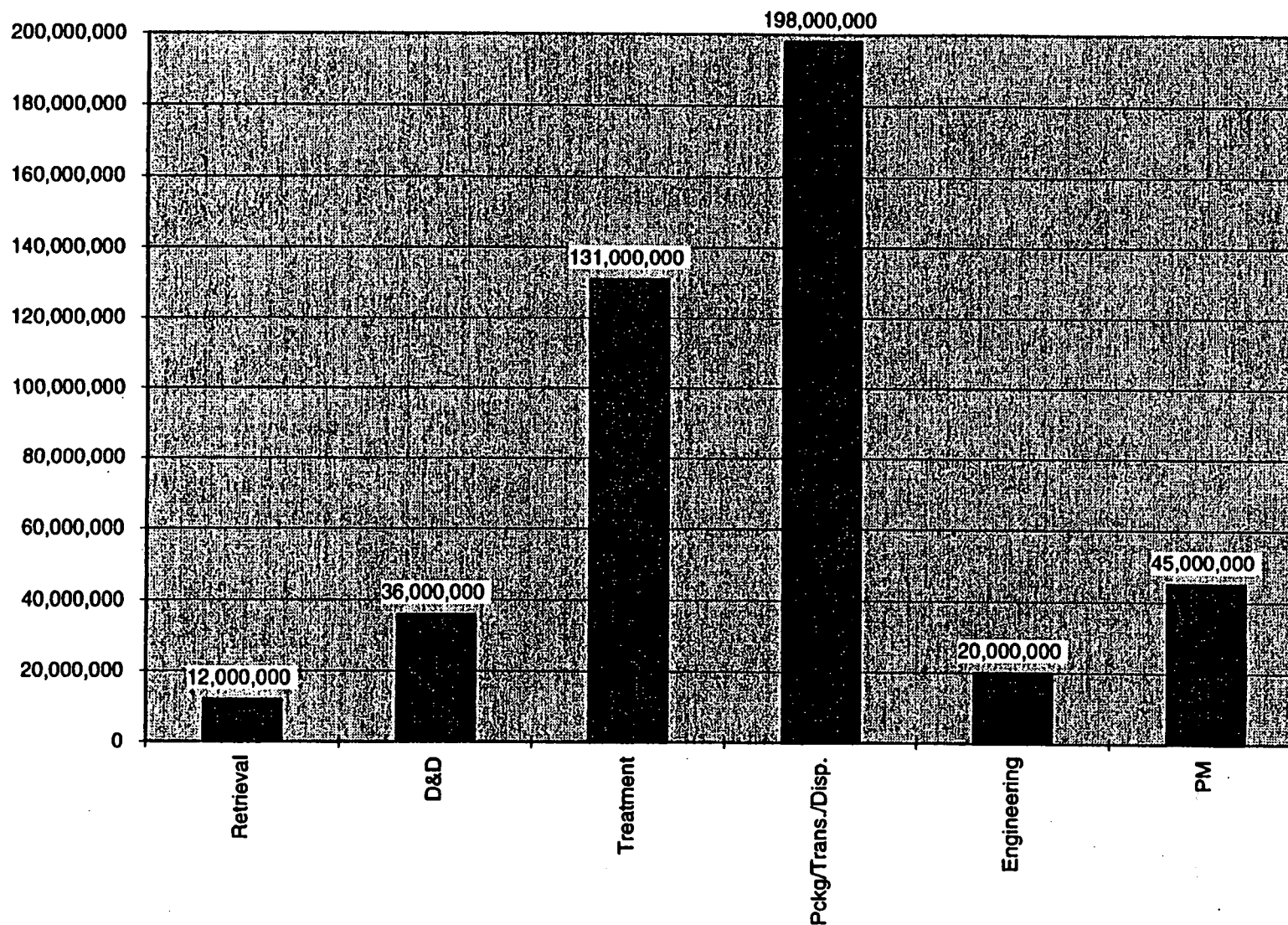


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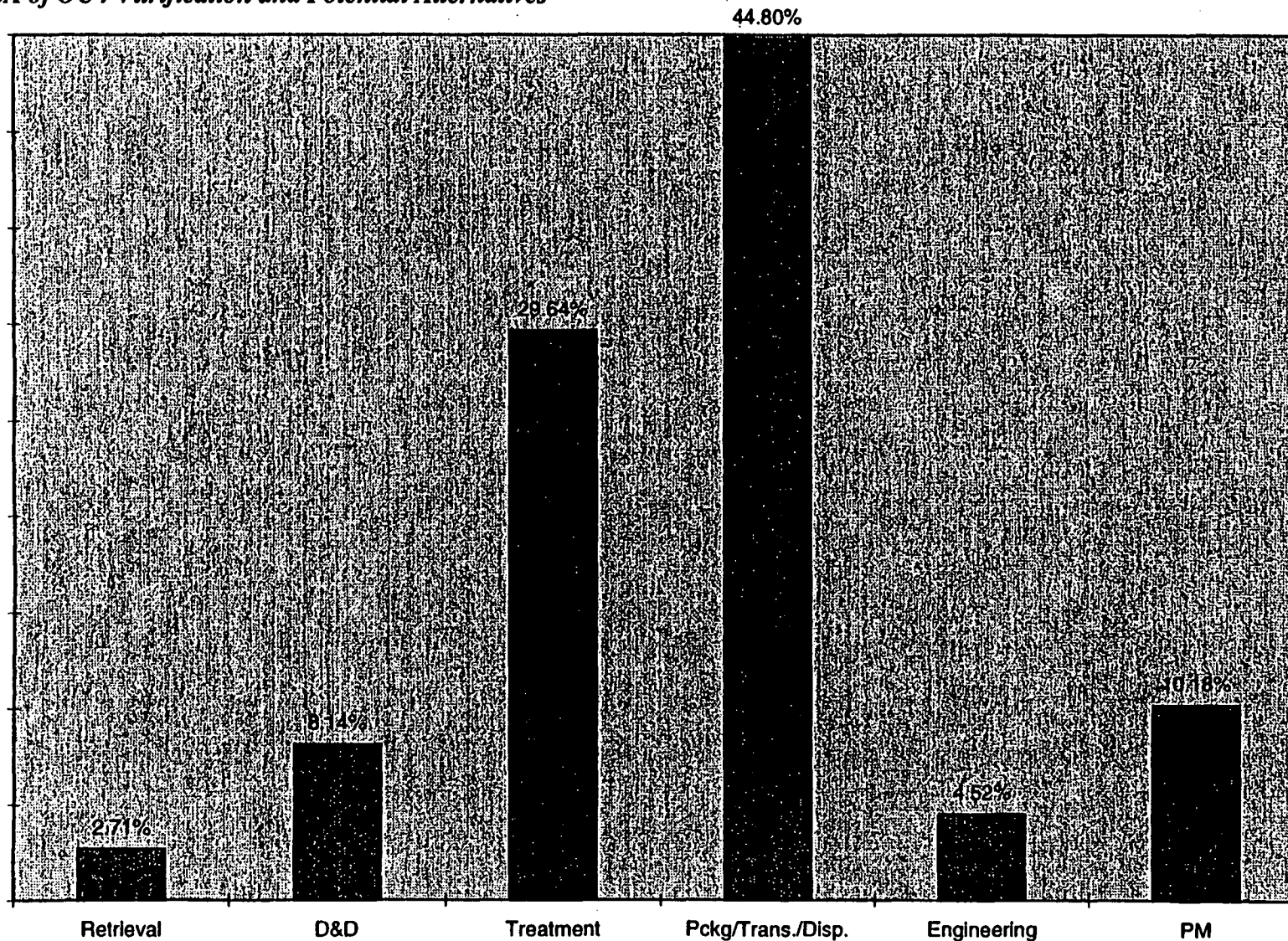


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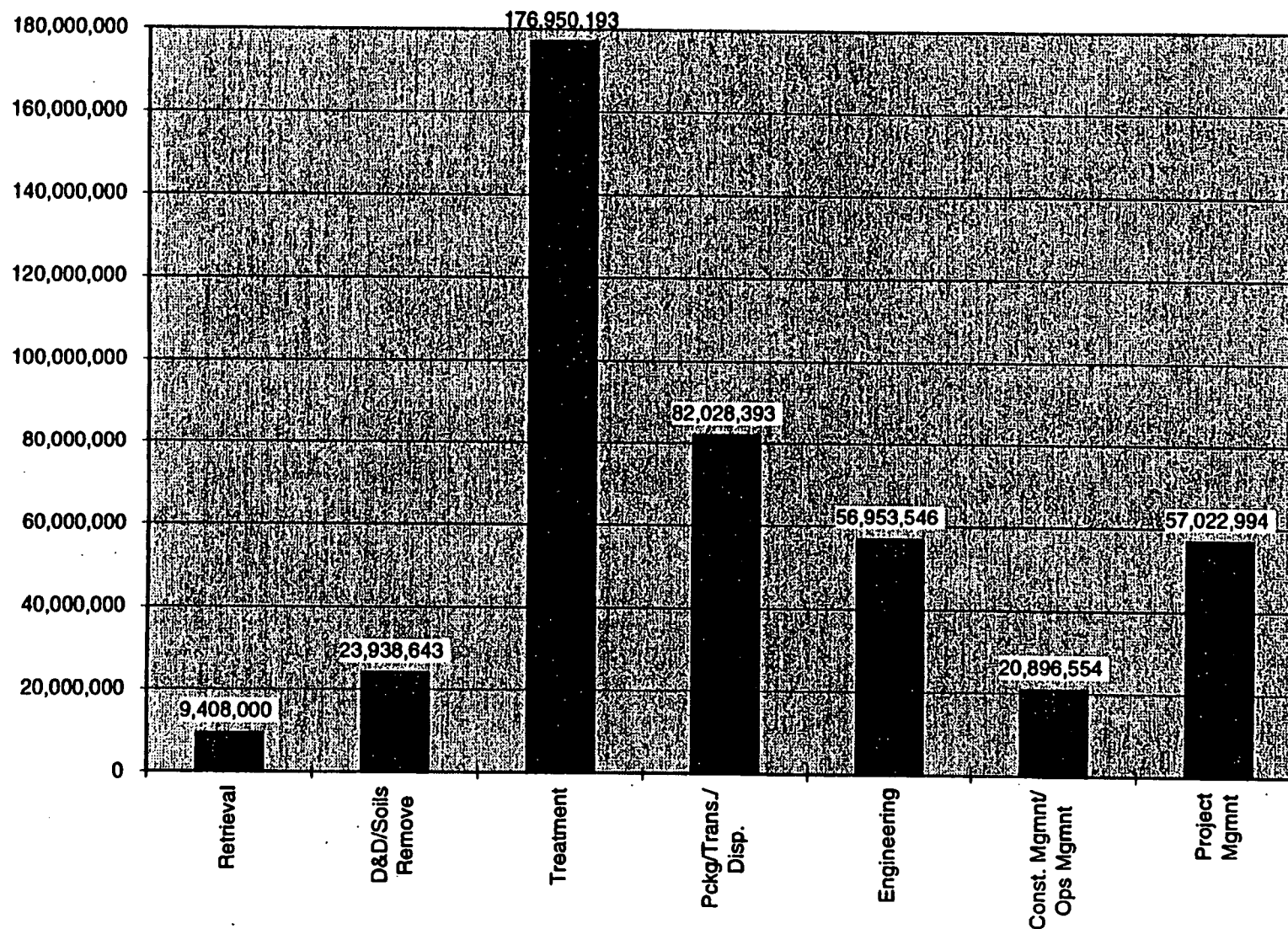


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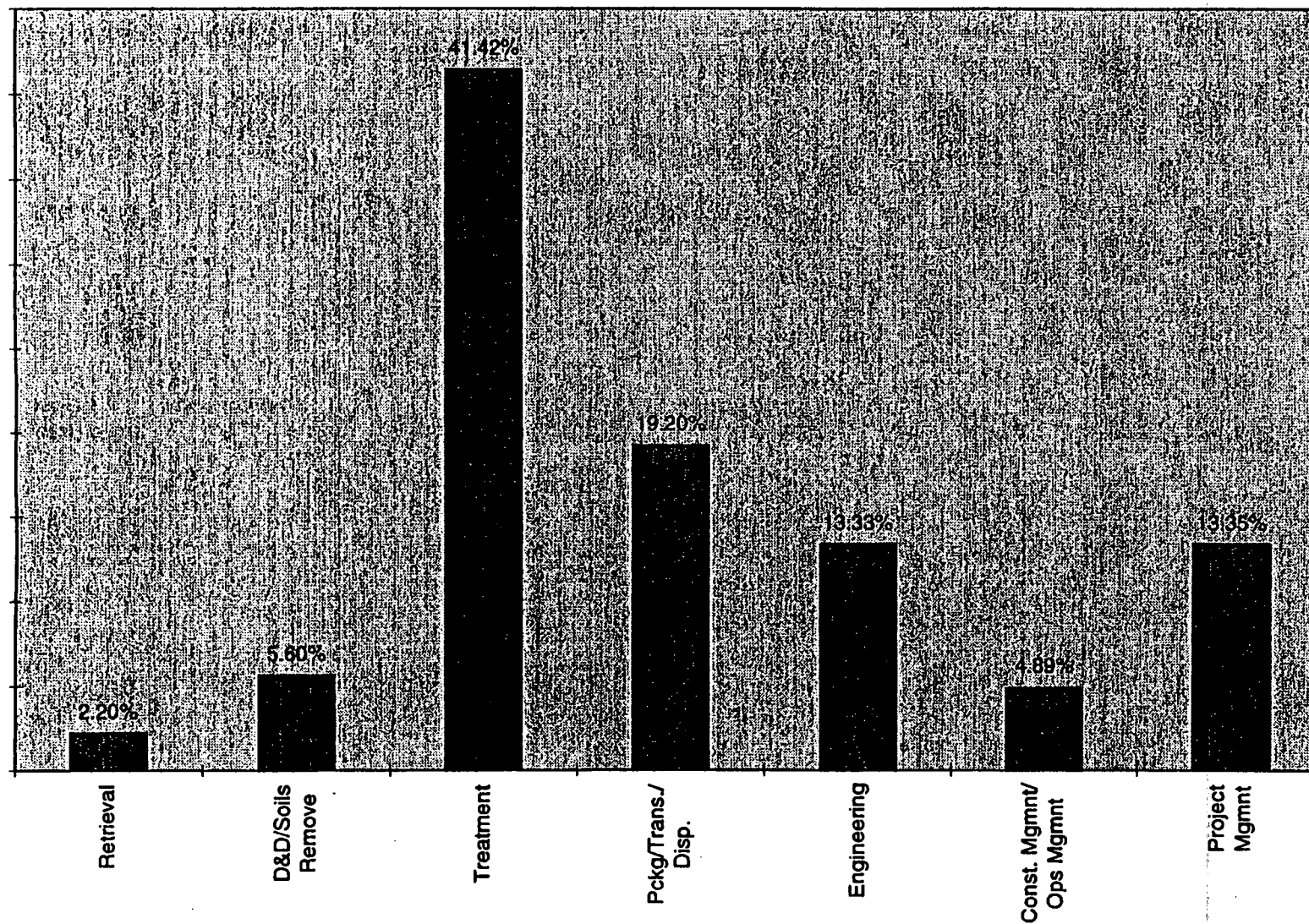
Basis of Charts

	Retrieval	D&D/Soils Remove	Treatment	Pckg/Trans/ Disp.	Engineering	Const. Mgmt/ Ops Mgmt	Project Mgmt	Totals
Alternative # 2 Total (from summary)	16,000,000	40,000,000	247,000,000	80,000,000	51,000,000		54,000,000	488,000,000
Alternative # 2 Direct (from below)	9,408,000	23,938,643	176,950,193	82,028,393	56,953,546	20,896,554	57,022,994	427,198,322
Alternative # 2 Total (from summary)	3.28%	8.20%	50.61%	16.39%	10.45%	0.00%	11.07%	100.00%
Alternative # 2 Direct (from below)	2.20%	5.60%	41.42%	19.20%	13.33%	4.89%	13.35%	100.00%
Pilot Vit Plant			8,011,526		1,107,291	824,801	1,034,941	10,978,559
Silo #3 Plant			3,569,500	9,566,600	7,612,000	655,900		21,404,000
Engineering					45,313,261			45,313,261
Vit Plant			103,369,167			17,282,500		120,651,667
Vit Plant Operation			62,000,000					62,000,000
Waste Transport/Disposal				69,565,217				69,565,217
D&D/Soils Removal		23,938,643		2,896,576	718,159	1,891,153	1,891,153	31,335,684
Project Management							54,000,000	54,000,000
Retrieval	9,408,000				2,202,835	242,200	96,900	11,949,935
							Total Direct:	427,198,322

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Appendix H

Memorandum, Technical Evaluation of FEMP Silo Waste Treatment and Disposal Project

**Project EM - Phase 2 Report
Fernald Environmental Management Project
CA of OU4 Vitrification and Potential Alternatives**

APR-21-1997 19:45

IDAHO FIELD OFFICE OFC

F.003/300

APR 21 '97 23:25AM AMWP & ENVIRONMENTAL RESTORATION

*John Kolits -
excellent work.*

United States Government

Department of Energy

Idaho Operations Office

memorandum

DATE: March 27, 1997

SUBJECT: Technical Evaluation of FEMP Silo Waste Treatment and Disposal Project
(OPE-MWFA-97-033)

TO: Jack R. Craig, Director
DOE-FEMP

I was recently asked through the Mixed Waste Focus Area to evaluate the current technical basis for the FEMP Silos 1, 2 and 3 treatment project and to act as technical advisor to the Corp of Engineers Value Engineering analysis of the Silos project. Prior to my visit to FEMP I reviewed in detail the origin of the Silo wastes, the chemical and radiological characteristics of the waste, CERCLA Feasibility Study for Operable Unit 4 and the final report of the Value Engineering (V-E) study issued in January 26, 1995. In addition, I independently reviewed data for glass formation, cement stabilization and alternate stabilization of waste similar to those present in Silos 1, 2 and 3.

As I discussed publicly in your FEMP Citizens Task Force meeting March 15, 1997, I found no technical justification for the conversion of the Silo 1, 2 or 3 contents to a vitrified glass product. Specific items that I found notable are the following.

- Everyone I spoke with at FEMP stated that glass product was not required by the NTS Performance Assessment or required by applicable transportation requirements. I was not able to obtain a copy of the PA and thus was not able to make an independent confirmation of this information.
- Joule vitrification of any waste materials carry with it numerous physical and mechanical risks related to heating materials to temperatures greater than 1000 C (1800 F). The most important of which, for FEMP, is metal formation, problems with redox control, foaming due to gas generation, volatilization of high vapor pressure materials, condensation of volatilized materials in the off-gas system and subsequent plugging, and general system corrosion. Salt phase separation can also be a problem but based on my analysis of the silo contents this should not occur. Recent failures of the FEMP and Oak Ridge Joule melter systems highlight the potential seriousness of problems associated with vitrification of heterogeneous waste materials.
- Test data generated at FEMP using the Toxic Characteristic Leach Procedures (TCLP) for cemented and vitrified Silo 1, 2 and 3 waste indicated that the cemented product had lower leach rates for all tested metals except radium-226, which does not have a specific leach requirement under RCRA. Due to the very low water infiltration rates at the NTS disposal site the increased leach rate of radium in the

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Jack R. Craig

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cemented product appears to me to pose an insignificant risk increase when compared to the significantly increased processing risks of vitrification.

- Information available on NTS disposal conditions and questions asked during my FEMP visit indicates that radon-222 release from the surface at NTS will be well below the NESHAP requirement of 20 pCi/m³s even if the silo waste receives no treatment. This is due to the long diffusion time to the surface as compared to the 3.82 day half-life of radon-222 at NTS disposal depths.

Based upon my analysis of the Silo 1, 2 and 3 hazardous and radioactive characteristics (which are relatively benign) and the risks involved with the high temperature vitrification of these same wastes I do not support the current efforts to vitrify these wastes. I believe that if you carefully review the wealth of scientific and technical information which has become available since the R/F/S recommendation was made (Feb 1994) that you will come to the same conclusion.

Analysis of all data made available, indicates to me that the preferred path forward would be to stabilize the silo wastes to the minimum extent possible such that the product meets the following criteria, 1) meets TCLP and NTS waste acceptance criteria, 2) meets minimum transportation requirements, 3) reduces waste volume cost effectively, do a cost trade-off analysis between volume reduction, shipping and disposal charges and added cost of shielding due to concentration of radioactive components into a smaller volume (smaller is not always better), and 4) use the most reliable treatment method available, for example don't use multi-step stabilization and material handling when a commercial batch plant with air control will do. My technical analysis indicates that actual removal of the waste from the silos may be the most difficult part of the task from a reliability standpoint (assuming vitrification is not used).

For the present I would recommend that the remaining Silo 1 and 2 test materials, which I believe are currently slated for glass formation testing, be used to do laboratory testing of 1) two or three different Portland and/or pozzolonic based stabilization methods at higher waste loadings than previously tested, 2) stabilization using commercially available Aquaset or Petroset, and 3) one or two different phosphate based methods. These should be done as small scale tests on commercially available materials only. Previous data in the OU4 Feasibility Study used waste loading around 22% due to a perceived 500 psi strength requirement. This strength is not needed. New formulations which meet all requirements may allow waste loadings near 70 or 80% to be achieved. Based upon the test results, a cost/risk analysis could be quickly done to choose the most reliable and cost effective stabilization approach. If FEMP, as a site, is comfortable with performance based contracting methods, I would suggest using the lab test data to write performance based treatment specifications and do a competitive procurement based upon payment per volume

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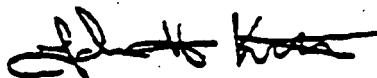
Jack R. Craig

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of waste treated. The performance based treatment specifications and stabilization method chosen can also provide the basis for your required OU4 ROD amendment, regulator and public review. Idaho has a fair amount of experience in performance based procurement and could probably provide some assistance if requested.

As a scientist I very much enjoyed the exposure to FEMP technical issues. I hope that in some small way my analysis and recommendations will be helpful. Please contact me at 208-526-9909 if I can be of any further assistance to you or your staff.



Dr. John H. Kolts
Principal Scientific Advisor

cc: P. H. Hamrin, DOE-OH
L. E. Stevens, DOE-OH
D. M. Maynor, DOE-OH
J. Reising, DOE-FEMP
D. Yockman, DOE-FEMP
C. Bauer, DOE-HQ, EM-50
W. E. Bergholz, DOE-ID
C. Nichols, DOE-ID

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 OPE-MWFA-97-033

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RECORD NOTES:

1. This memo was prepared to report my trip to Fernald.
2. This memo was written by John Kolts.
3. This memo closes CATS number N/A.
4. The attached correspondence has no relation to the Naval Nuclear Propulsion Program. Naval Reactors concurrence is not required.

JKolts(OPE-MWFA):by:mg,6-3780,3-27-97,o:\division\mwfa\entfil.97\97-033.wpd

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US DOE OHIO FIELD OFFICE

513 565 4402 F.002-003

John Henry Kolts
Principle Scientist
U.S. Department of Energy - Idaho

EDUCATION

- Ph.D. in Physical/Analytical Chemistry, Kansas State University, Manhattan, Kansas, 1978
- BS (Cum Laude) in Chemistry with minor in Zoology, Weber State College, Ogden, Utah, 1974

CURRENT PROFESSIONAL HIGHLIGHTS

Mr. Kolts is a holder of 56 United States Patents, over 200 foreign patents and author of numerous technical publications.

EXPERIENCE

Professional Employment: 16 years

- Principle Scientist Advisor, DOE-IDER, Waste Management and site wide Research & Development Programs.
- Morrison Knudsen Corporation. Senior Scientist and Technical Director for the Government Facilities and Environmental Services Division. Responsibilities included selecting, coordinating and implementing technology for the remediation efforts at Oak Ridge, Rocky Flats, Fernald, and the Idaho National Engineering Laboratory.
- EG & G, Idaho. Principle Scientist, EG&G Idaho, Technology Director for the Environmental Restoration and Waste Management Department. Responsibilities included coordinating, approving and directing the implementation of environmental and waste management programs at the Idaho National Engineering Laboratory. Additional responsibilities included providing direction on RI/FS studies, Records of Decision, RD/RA actions, as well as supporting DOE with State of Idaho and EPA technical issues, and directing the Strategic Planning Unit for the INEL in Environmental Engineering and Waste Management and being a representative to the University of Idaho and Idaho State. Also responsible for the technical oversight of all Pit 9 remediation activities.
- Phillips Petroleum. Phillips Petroleum Company, Research Associate responsible for the direction of a diversified research group. Specific technical and management responsibilities were

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U.S. Army Corps of Engineers ♦ DOE Office of Environmental Management

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light and heavy hydrocarbon process research and development,
direct methane conversion, new waste treatment techniques, and
waste minimization research and development. 1978 - 1990.

PATENTS, PUBLICATIONS, AWARDS

- In addition to holding numerous U.S. and foreign patents, Mr. Kolts received the National R&D 100 Award for developing one of the top 100 new commercial products for the year 1989.

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Feasibility Study Remedial Alternatives

Operable Unit 4 Subunit	Alternative	Description
<u>Subunit A</u> Silos 1 and 2 contents and decant sump tank sludge	0A 2A/VIT 2A/CEM 3A.1/VIT 3A.1/CEM	No action Removal, vitrification, on-property disposal Removal, cement stabilization, on-property disposal Removal, vitrification, off-site disposal at NTS Removal, cement stabilization, off-site disposal at NTS
<u>Subunit B</u> Silo 3 contents (cold metal oxides)	0B 2B/VIT 2B/CEM 3B.1/VIT 3B.1/CEM 4B	No action Removal, vitrification, on-property disposal Removal, cement stabilization, on-property disposal Removal, vitrification, off-site disposal at NTS Removal, cement stabilization, off-site disposal at NTS Removal and on-property disposal
<u>Subunit C</u> Silos 1, 2, 3, and 4 structures, soils, debris	0C 2C 3C.1 3C.2	No action Demolition, removal, on-property disposal Demolition, removal, off-site disposal at NTS Demolition, removal, off-site disposal at permitted commercial disposal site

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Table I2
Evaluation Criteria

1. **Overall protection of human health and the environment:** Examines whether a remedy would provide adequate overall protection to human health and the environment. Evaluates how risks would be eliminated, reduced, or controlled through treatment, engineering controls, or institutional control included in the alternative.
2. **Compliance with Applicable or Relevant and Appropriate Requirements (ARARs):** Determines if a remedy would meet all pertinent environmental laws and policy siting requirements.
3. **Long-term effectiveness and permanence:** Evaluates the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup goals have been met.
4. **Reduction of toxicity, mobility, or volume through treatment:** Reviews the anticipated performance of the proposed treatment technologies for their abilities to reduce the hazards of, prevent the movement of, or reduce the quantity of waste materials.
5. **Short-term effectiveness:** Evaluates the ability of a remedy to achieve protection of workers, the public, and the environment during construction and implementation.
6. **Implementability:** Examines the practicality of carrying out a remedy, including the availability of materials and services needed during construction and operation.
7. **Cost:** Reviews both estimated capital, operation and maintenance costs of the remedy. Cost are represented as present worth costs. "Present worth" is defined as the amount of money that, if invested in the first year of implementing a remedy and paid out as needed, would be sufficient to cover all costs associated with the remedy over its planned life. Present worth costs allow remedies that would occur over different time periods to be compared on an even basis.
8. **State acceptance:** Evaluates the technical and administrative issues and concerns the State of Ohio may have regarding each of the alternatives (will be addressed in the Comment Responsiveness Summary made available with the Record of Decision).
9. **Community acceptance:** Evaluates the issues and concerns of the public regarding each of the alternatives (will be addressed in the Comment Responsiveness Summary made available with the Record of Decision).

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Table I3
Evaluation of Remedial Alternatives

Evaluation Criteria	Subunit A - Silos 1 and 2 Contents					Subunit B - Silo 3 Contents						Subunit C - Silos 1, 2, 3, and 4 Structures, Soils, and Debris			
	0-A	2A/Vit	2A/Cem	3A.1/Vit	3A.1/Cem	0-B	2B/Vit	2B/Cem	3B.1/Vit	3B.1/Cem	4-B	0-C	2-C	3C.1	3C.2
1. Overall Protection Health & Environment	⊗	●	●	●	●	⊗	●	●	●	●	●	∅	● ¹	●	●
2. Compliance with ARARs	⊗	● ²	● ²	●	●	⊗	● ²	● ²	●	●	●	∅	● ²	●	●
3. Long-term Effectiveness and Permanence	⊗	∅	∅	●	●	⊗	∅	∅	●	●	∅	∅	●	●	●
4. Reduction of Toxicity, Mobility, or Volume through Treatment	NA	●	∅	●	∅	NA	●	∅	●	∅	NA	NA	NA	NA	NA
5. Short-term Effectiveness	⊗	●	●	●	●	⊗	●	●	●	●	●	NA	●	●	●
6. Implementability	NA	●	●	●	●	NA	●	●	●	●	●	NA	●	●	●
7. Total Present Worth Cost (\$ Million)	0	43.6	74	43.7	73.1	0	28	37.4	28	36	22	0	34.3	75.5	44
8. State Acceptance	State acceptance of the recommended alternative will be evaluated after the public comment period.														
9. Community Acceptance	By either filling out and returning the attached comment sheet or by verbally commenting on the Proposed Plan during public meeting, interested members of the public can voice their opinion on which parts of the alternative they support, which parts they have reservations about, and which parts they oppose. Community acceptance will be assessed after the public comment period and will be addressed in the Responsiveness Summary of the Record of Decision document.														

● Fully meets criteria ∅ - Partially meets criteria ⊗ - Does not meet criteria NA - Not Applicable

1 - Assessment of protectiveness adopts the use of continued federal government ownership and evaluates risk to expanded trespasser and the off-property farmer.

2 - Assumes substantive technical requirements for Ohio Disposal facility siting are met.

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Appendix J

Cost Estimate Analysis Details

J.1 Cost Duplications

The following series of tables include cost information that can be traced directly to OU4 remediation project supporting documentation. Italicized text indicates areas of duplication. Note that base estimate dollars do not include contingency. Cost duplications are identified in five categories:

- Silo 3 Stabilization Cost
- Final Remediation Engineering Cost
- Final Remediation Construction Cost
- Waste Packaging/Shipping/Disposal Cost
- Project Management Cost

Silo 3 Stabilization Cost is divided into the following major components as shown in Table J1.

Table J1

Component Description	Cost (\$)
<i>Silo 3 Direct Field Costs</i>	2,032,600
<i>Silo 3 Indirect Field Costs</i>	1,536,940
<i>Silo 3 FDF Field Support Costs</i>	655,900
<i>Silo 3 Engineering Costs</i>	7,612,000
Operation Costs	10,714,600
Total Base Estimate	\$22,552,040

Final Remediation Engineering Cost is divided into the following major components as shown in Table J2.

Table J2

Component Description	Cost (\$)
Silos 1 and 2 Engineering Costs	26,222,900
<i>Silo 3 Engineering Costs</i>	7,612,000
Engineering Management/System Engineering	8,000,000
Melter Development Engineering	*5,280,000
Total Base Estimate	\$47,114,900
* Assumes twelve engineers at \$220,000 per year for two years.	

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Final Remediation Construction Cost is divided into the following major components as shown in Table J3.

Table J3

Component Description	Cost (\$)
Vitrification Direct Field Costs	44,333,400
Silo 3 Direct Field Costs	2,032,600
Subtotal Direct Field Costs	\$46,366,000
Vitrification Indirect Field Costs	40,336,530
Vitrification FDF Field Support Costs	17,282,500
Total Base Estimate	\$103,985,030

Several costs in the preceding tables appear more than once. Silo 3 direct field costs appear in Silo 3 Stabilization Cost and in Final Remediation Construction Cost. Silo 3 engineering costs appear in Silo 3 Stabilization Cost and Final Remediation Engineering Cost. Vitrification civil and excavation and vitrification concrete costs appear twice in Final Remediation Construction Cost. The net error resulting from the duplications is calculated in Table J4.

Table J4

Description	Cost (\$)
Summary by Current Category Base Estimates	
Silo 3 Stabilization Cost	22,552,040
Final Remediation Engineering Cost	47,114,900
Final Remediation Construction Cost	103,985,030
Current Base Estimate	\$173,651,970
Summary by Unique Components	
Silo 3 Direct Field Costs	2,032,600
Silo 3 Indirect Field Costs	1,536,940
Silo 3 FDF Field Support Costs	655,900
Silo 3 Engineering Costs	7,612,000
Operation Costs	10,714,600
Silos 1 and 2 Engineering Costs	26,222,900
Engineering Management/System Engineering	8,000,000
Melter Development Engineering	5,280,000
Vitrification Direct Field Costs	44,333,400
Vitrification Indirect Field Costs	40,336,530
Vitrification FDF Field Support Costs	17,282,500
Total Unique Components	\$164,007,370
Net Error from Base Estimate Duplications	\$9,644,600

Certain duplicated cost components tabulated earlier have additional cost impacts. Specifically, Silo 3 direct field costs, vitrification civil and excavation costs and vitrification concrete costs are

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duplicated in the vitrification direct field costs subtotal shown in Table J3. These three components affect vitrification indirect field costs and estimated FDF field support costs (calculated as percentage of direct). The total net error also affects the contingency calculation. Additional cost reductions can be calculated from the following components of the category Final Remediation Construction Cost and the total net error calculated in Table J4:

Total labor for the three components	\$414,800
Total material/equipment for the three components	\$1,617,700
Total direct for the three components	\$2,032,600

Table J5 summarizes additional ramifications.

Table J5

Indirect Field Cost Item	Calculation	Cost (\$)
Supervision - Contractor	17% of labor	70,516
Small Tools and Consumables	6% of labor	24,888
Health Physics S/C	1.15% of labor	4,770
Training	0.14% of labor	581
Payroll Burdens and Benefits	74% of labor	306,952
Overhead/Profit/Bond	32% of direct	650,432
Sales Tax - Material	6.5% of material/equipment	105,151
FDF Field Support	37% of total direct	752,062
Contingency	20% of net error	1,928,920
	Total Additional	\$3,844,272
Table Note: All percentages were calculated using current OU4 support documentation.		

A cost duplication was also identified in the Waste Packaging/Shipping/Disposal Cost category, pertaining to the application of contingency. Two types of contingency are added to the current OU4 remediation project estimate. A risk budget is included in the backup documentation as part of the target estimate. A contingency is then applied to the target estimate to establish each category cost. Applying a risk budget and a contingency is common practice through the estimate supporting documentation.

In the case of the Waste Packaging/Shipping/Disposal category, a risk budget and contingency is applied prior to a final contingency application to establish the current estimate category cost. Table J6 depicts the current estimated cost for this category.

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Table J6

Component Description	Cost (\$)
Direct and Indirect Field Costs	25,089,460
Sales Tax	703,700
Risk Budget (10.7%)	2,759,900
Contingency (22.6%)	6,452,992
Subtotal Category	\$35,006,052
*Multiply x 2	x 2
New Subtotal Category	\$70,012,104
Contingency (15%)	10,501,815
New Total Category	\$80,513,919
* Multiply x 2 to account for packaging/shipping/disposal OU4 soils. This item is discussed further in section J.2 of this appendix.	

Table J6 clearly shows contingency applied two times. The net error identified for the Waste Packaging/Shipping/Disposal category is the additional 15% contingency, amounting to \$10,501,815.

Finally, potential cost duplications were identified in the Project Management (PM) cost category.

The current estimated cost for this category, including contingency, is \$54 million. The breakdown is shown in Table J7.

Table J7

Component Description	Cost (\$)
Sum Highlighted Actuals for Fiscal Year 1996	1,567,000
*Multiply x 2	x 2
Subtotal Category per Year	\$3,134,000
Multiply x 15 years	x 15
New Subtotal Category	\$47,010,000
Schedule Extension for Melter Development Addition	6,000,000
New Total Category	\$53,010,000
* Due to "lack of resources to manage a project of this magnitude." This item is discussed further in section J.2 of this appendix.	

Note that as estimated, the current PM cost exceeds 11% of the total remediation project OU4, which is well above industry standards (discussed in the following text). In addition to the PM cost category estimate, Construction Management (CM) costs were found in other categories throughout the supporting documentation. Table J8 summarizes additional CM considered as potential cost duplication.

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Table J8

Description	Cost (\$)
Silo 3 Stabilization CM	655,900
Final Remediation Construction CM	17,282,500
D&D/Soils Remediation CM	608,000
Waste Retrieval PM	96,900
Waste Retrieval CM	242,000
Total Potential Duplication	\$18,885,300

Table J9 summarizes duplicated and potentially duplicated costs identified in the OU4 remediation project supporting documentation.

Table J9

Description	Cost (\$)
Net error duplicated cost found in Silo 3 Stabilization, Final Remediation Engineering and Final Remediation Construction cost categories	9,644,600
Additional net error ramifications	3,844,272
Contingency duplication for Waste Packaging/Shipping/Disposal cost category	10,501,815
Potential duplication for PM cost category	18,885,300
Potential PM duplication contingency (20%)	3,777,060
Total Potential Cost Duplications Result	\$46,653,047

It is important to note that the total affect of identified and potential cost duplications equal over 12% of the current cost estimate for the OU4 remediation project. This indicates a serious deficiency of quality control with respect to estimate support documentation upkeep.

J.2 Unsupported Cost Additions

Two unsupported cost additions included in the support documentation will be discussed in detail. The first addition affects costs in the Waste Packaging/Shipping/Disposal and D&D/Soils Remediation cost categories. The unsupported cost addition is italicized in Table J10, depicting the Waste Packaging/Shipping/Disposal Cost category.

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Table J10

Component Description	Cost (\$)
Direct and Indirect Field Costs	25,089,460
Sales Tax	703,700
Risk Budget (10.7%)	2,759,900
Contingency (22.6%)	6,452,992
Subtotal Category	\$35,006,052
*Multiply x 2	x 2
New Subtotal Category	\$70,012,104
Contingency (15%)	10,501,815
New Total Category	\$80,513,919
* Multiply x 2 to account for packaging/shipping/disposal OU4 soils.	

It is clear from Table J10 that \$35,006,052 was added to the estimate without supporting data. During the week of the VE study, an on-site representative initially indicated that the amount was added to account for vittrification and disposition of the soils beneath Silos 1 and 2. It was pointed out to the individual that this assumption had been changed to accommodate an IRT recommendation that the soil be shipped and disposed of in white metal boxes (WMB) without vittrification. Subsequently, the individual indicated that the amount was added to account for 100% of the following to be packaged in WMBs and shipped to NTS for disposal:

- Five-foot deep section under Silos 1 and 2
- Berm soils around Silos 1 and 2
- Six-inch depth across the OU4 site area

To assume that 100% of the listed soils be packaged, shipped and disposed of at NTS is completely unsubstantiated. Furthermore, a factor of two applied to an unrelated cost item (waste quantity inside the silos) is an inappropriate method of estimating. It is important to note that excavation of the soils is accounted for in the D&D/Soils Remediation Cost category. For comparison purposes, the team makes the following assumptions based on professional judgement:

- A five-foot section under Silos 1 and 2 is contaminated.
- A two-foot zone of berm soil adjacent to Silos 1 and 2 is contaminated.
- 50% of the remaining berm soil and six inch stripped soil quantity will be disposed of on-site.
- 50% of the remaining berm soil will be non-contaminated and used as backfill.

Note that all unit costs used for this comparison are taken from current estimate support documentation. Table J11 summarizes a comparative cost based on the stated assumptions.

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Table J11

Description	Quantity	Unit Cost (\$)	Cost (\$)
Waste Containers (WMB)	1,130 ea	800	904,000
Transportation	283 ea	3,200	905,600
Container Burial	125,091 cf	20	2,501,820
On-site Burial	31,958 cy	49.30	1,575,529
	Total		\$5,886,949
Table Notes:			
1. Qty WMBs = 3,891 l cy/ 3.1 cy/WMB x 0.9 packing efficiency			
2. Qty transports = Qty WMBs / 4 WMBs/transport			
3. Qty burial = Qty WMBs x 4.1 cy/WMB (exterior volume) x 27 cf/cy			
4. Qty on-site burial = 63,915 l cy x 0.5 (50%)			
5. Quantity Take Off was performed to determine volumes			

A substantial amount of cost benefits has been identified in the earlier comparison. Table J12 summarizes the cost benefits.

Table J12

Description	Cost (\$)
Current Estimated Amount	35,006,052
Estimated Comparative Amount	5,886,949
Subtotal Difference	\$29,119,103
Contingency (15%)	4,367,865
Total Cost Benefits	\$33,486,968

The second unsupported cost addition to be examined in detail affects the PM Cost category. The current estimated cost for this category including contingency is \$54 million. The breakdown is as follows in Table J13.

Table J13

Component Description	Cost (\$)
Sum Highlighted Actuals for Fiscal Year 1996	1,567,000
*Multiply x 2	x 2
Subtotal Category per Year	\$3,134,000
Multiply x 15 years	x 15
New Subtotal Category	\$47,010,000
Schedule Extension for Melter Development Addition	6,000,000
New Total Category	\$53,010,000
* Due to "lack of resources to manage a project of this magnitude."	

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A statement that "Project Management of this project [OU4] was reviewed, and it was determined that there was a lack of resources to manage a project of this magnitude," does not adequately justify or support an addition to the estimate of \$1,567,000 per year for 15 years, or \$23,505,000. It is true that more management will be needed during specific portions of the project such as operations. However, PM costs will vary depending on the work load. Hence, the needed quantity of PM will decrease as the project shuts down. Furthermore, as stated earlier, CM activities are included elsewhere in the estimate.

Additional problems with the supporting documentation were identified. The estimate for PM is based on FY96 and first quarter FY97 actuals. The team was provided a list of tasks (line items) used to accumulate the estimated yearly figure. A total of seventeen tasks were identified as being used in the estimate. Several of the tasks appear inappropriate for PM tasks:

- Facility Ownership – General Tasks
- Facility Ownership – Radiological Support
- Decant Sump Tank Maintenance
- Silos 3 and 4 Handrail
- Silos 1 and 2 Camera Replacement
- Rental of Portable Restroom
- Radon Treatment System Upgrade

The ten remaining tasks appear as appropriate PM tasks. However, facility ownership tasks should be considered in site "hotel" costs, which were not analyzed in this effort. The remaining tasks listed previously should be considered direct costs. The seven tasks listed account for \$320,000 of the estimated yearly figure of \$1,567,000.

For comparison purposes, benchmarking data is used to estimate a more reasonable PM cost for the OU4 remediation project. Information is taken from the "Assessment of Site Support Services at the Fernald Environmental Management Project Cost Benchmarking" report prepared by Logistics Management Institute in February 1996. According to the report, contract administration and management costs should range from 4% to 6% of total budgeted project costs. The current estimate of \$54 million is over 11% of the total estimated project cost.

It was later pointed out by site estimating personnel that the summary estimate for the PM cost category was intended to include additional considerations. Specifically, it includes certain facility ownership, environmental monitoring and compliance, project engineering, and non-technical support costs not included elsewhere in the current estimate. The actual PM portion of the category value comprises approximately 7% of the total project estimate.

Other cost additions to the current OU4 remediation project estimate include the following:

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- 1) An addition of \$8 million before contingency to the Final Remediation Engineering Cost category for Engineering Management and System Engineering (Conceptual Design). With the assumed 15% contingency, this equates to \$9.2 million.
- 2) An addition of \$20 million including contingency to the Final Remediation Construction Cost category for "construction modification after one year surrogate test with first melter."
- 3) An addition of \$15 million including contingency to the Final Remediation Operation Cost for "the one year surrogate testing with the first melter."

No supporting documentation was provided to account for these additions to the current estimate. Therefore, no comparisons or comments are noted. However, it is recommended that a detailed accounting of these large allowances would be more appropriate to support the current estimate.

J.3 Detailed Analysis

A detailed review was also performed on the estimate support data provided to the team. This review included a random sampling of detailed line items. Direct cost components for these items were validated against existing industry standards from two sources: 1) USACE NAT95A UPB and 2) "Means Estimating Manual." Other comparisons were made based on stated assumptions on a case-by-case basis.

Prior to conducting the comparison of estimate line items, a standard adjustment was developed to apply to industry standard outputs, accounting for losses experienced on DOE field sites. It was assumed that all new construction would be performed in OSHA Level D (or equivalent) personal protective equipment. This implies wearing coveralls, safety boots, safety glasses, a dust mask and a hard hat. According to the "Hazardous, Toxic, and Radioactive Waste Productivity Study for Remedial Action Work," October 1994, the standard productivity factor for heavy work performed in Level D personal protective equipment is 0.92. This factor accounts for standard losses (such as safety meetings, instructions, change-outs and decontamination), scheduled/heat stress breaks and dexterity losses. The factor is calculated based on a 430 minute productive day under clean site conditions. Because the work for OU4 will be performed on a DOE site, two hours of a standard eight-hour shift were added to this factor or an additional 25% reduction. This two-hour addition accounts for other meetings and security considerations. The productivity factor established for the following comparisons is 0.67.¹⁰ Hence, all unit personhours taken from the NAT95A UPB or "Means Estimating Manual" are increased by a multiplier of 1.4925 (1/.67).

The Fernald Environmental Restoration Management Corporation (FERMCO) budget estimate details include only labor, material and/or capital equipment costs. Equipment (as associated with a crew) is estimated as a separate line item entitled miscellaneous equipment rental. Therefore, crew equipment costs, calculated using hourly ownership rates in the two sources used, are not included in the detailed comparisons. Note that comparisons are made on direct costs only. It is evident that differences in direct costs also affect indirect costs, payroll burdens, contingency and other costs calculated as percentages of direct costs.

¹⁰ Calculated as $[1 - (0.08 + 0.25)]$.

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Silo 3 Stabilization Cost Category

Comparison 1 - Slab on Grade

Source	Qty	mhs/ Unit	Total mhs	Labor Rate	Labor (\$)	Mat (\$)	Total (\$)
FEMP Budget Estimate	185 cy	5.00	925	20.11	18,600	20,800	39,400
NAT95A UPB	185 cy	2.43	450	20.11	9,050	20,800	29,850
Direct Cost Difference							\$9,550

Table Notes:

1. UPB unit mhs includes formwork (5.41 lf/cy), weld wire reinforcement, placing slab on grade and finishing
2. FEMP budget estimate material cost accepted

Assume in Comparison 1 that placement and finishing of concrete is 50% of the FEMP budget estimate unit personhours. The unit personhours of 2.50 equates to 2.40 cy per crew hour, assuming a six-member crew. This further equates to 19.2 cy per eight-hour day or just over two truckloads of concrete. This appears to be unreasonably low compared to industry standards.

Comparison 2 - Structural Steel

Source	Qty	mhs/ Unit	Total mhs	Labor Rate	Labor (\$)	Mat (\$)	Total (\$)
FEMP Budget Estimate	40 ton	22.00	880	21.71	19,100	58,000	77,100
Means Construction Cost	40 ton	11.26	450	21.71	9,770	58,000	67,770
Data							
Direct Cost Difference							\$9,330

Table Notes:

1. Means reference number 051 255 1600
2. FEMP budget estimate material cost accepted

Comparison 3 - Job Clean-up

Source	Qty	mhs/ Unit	Total mhs	Labor Rate	Labor (\$)	Mat (\$)	Total (\$)
FEMP Budget Estimate			890	21.01	18,700	6,220	24,920
Professional Judgment of the Team			200	21.01	4,202	1,000	5,202
Direct Cost Difference							\$19,718

Table Notes:

1. The Project EM team assumed a five-member crew for a one-week duration.
2. No support documentation found for the FEMP budget estimate.

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Comparison 4 - Engineering/Design/Inspection

Source	Total mhs	Labor Rate	Total (\$)
FEMP Budget Estimate	69,200	110	7,612,000
Professional Judgment of the Team	7,685	110	845,350
Direct Cost Difference			\$6,766,650

The current FEMP budget estimate is based on 20 full-time equivalents (FTEs) x four months + twenty-five FTEs x eight months + 10 FTEs x twelve months. The cost equates to 180% of (direct + indirect + construction mgmt) costs for construction of a solidification facility. This amount appears excessive for construction of a batching facility, a commonly used technology. It is interesting to note that in previous documentation supporting the FEMP budget estimate, the engineering/design/inspection was estimated at \$876,700 for the same facility. The professional judgment estimate is based on 20% of (direct + indirect + construction mgmt) costs.

Comparison 5 - Unit Disposal Cost

Source	Qty	Unit Cost (\$)	Total (\$)
FEMP Budget Estimate	241,920 cf	20	4,838,400
Professional Judgment of the Team	241,920 cf	17	4,112,640
Direct Cost Difference			\$725,760

The FEMP budget estimate is based on projected disposal costs for FY98 and a 12% risk budget. This projection appears to include escalation, which is inconsistent with other supporting documentation. Escalation is added later in the estimating process. The professional judgment unit cost is based on current charges for low-level radioactive waste (LLRW) buried in metal boxes at NTS, as incurred by Idaho National Engineering and Environmental Laboratory (INEEL) and the Savannah River Site. Information was found in a document prepared for the USACE titled "Cost Standards for Comparing Baseline Estimates to Demonstration Estimates - Waste Disposal Costs," January 1997. It is also noted here that the unit disposal rate used for Silos 1 and 2 waste in the FEMP budget estimate supporting documentation is \$17.66 per cubic foot.

Final Remediation Construction Cost Category

The civil and excavation, concrete, structural steel and architectural original vitrification estimates were prepared for a four to six MT/D melter alternative (Alternative 1). The three to six MT/D melter vitrification facility (Alternative 2) estimates for these components were factored from Alternative 1 based on personhours and material costs per square foot building area. Documentation was found supporting the method used. Resulting material costs were accurately transferred to the Alternative 2 estimate support data. However, the resulting factored personhours were not accurately transferred. In fact, personhours for these components were

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increased by 17% to 28% from the original estimate for Alternative 1. The result of this error in transfer of calculated data is summarized in Table J14.

Table J14

Component Description	Factored Alt 2 mhs	Current Estimate Alt 2 mhs	Error mhs	Labor Rate	Error (\$)
Civil and Excavation	7,645	9,860	2,215	19.09	42,284
Concrete	115,489	148,980	33,491	20.11	673,504
Structural Steel	28,843	37,210	8,367	21.71	181,648
Architectural/Buildings	60,402	77,920	17,518	20.30	355,615
Total Error					\$1,253,051

In addition to problems with the scaling for Alternative 2, review of the base estimate (Alternative 1) indicates that similar problems exist, as are evident in the construction of the solidification facility in the Silo 3 Stabilization Cost category.

Waste Packaging/Shipping/Disposal Cost Category

Comparison 1 - Package and Load Containers

Source	Qty	mhs/ Unit	Total mhs	Labor Rate	Total (\$)
FEMP Budget Estimate	3,200 ea	11.46	59,944	21.56	1,292,400
Professional Judgment of the Team	3,800 ea	2	7,600	21.56	163,856
Direct Cost Difference					\$1,128,544

Table Notes:

1. FEMP budget = 0.06 mhs packaging + 11.4 mhs loading
2. Professional judgment based on zero mhs packaging (assume package/stage during operations) + 2 mhs loading (assume four-member crew can load two containers per hour)
3. Quantity of 3800 each was taken from documentation supporting the estimates.

Comparison 2 - Disposal

Source	Qty	Unit Cost (\$)	Total (\$)
FEMP Budget Estimate	419,000 cf	17.66	7,399,540
Professional Judgment of the Team	502,740 cf	17	8,546,580
Direct Cost Difference			\$(1,147,040)

Table Notes:

1. FEMP waste volume could not be traced (based on 3,200 containers)
2. Professional Judgment based on 3,800 containers by external volume of 4.9 cy (3,800 x 4.9 x 27cf/cy)
3. Reference Comparison 5 under Silo 3 Stabilization Cost Category for unit cost

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The quantity of containers was inconsistent within the supporting documentation gathered during the VE study. The estimate support documentation did not match the documentation used (3,800). The error noted also affects total material and shipping costs of containers.

D&D/Soils Remediation Cost Category

The current baseline estimated cost for this category with contingency equals \$40 million. Support documentation provided was disorganized, inconsistent and hard to follow. Although technical content and scope of work statements were clear, the ability to track costs to the current baseline amount did not exist. Spreadsheets of varying formats were included in the support documentation; but its organization was in disarray. It is recommended that the support documentation for this category be packaged in an orderly and consistent manner before detailed comparisons are performed.

Waste Retrieval Cost Category

Table J15 summarizes Waste Retrieval Cost before contingency, which could be tracked using FEMP budget estimate summary sheets.

Table J15

Major Component	Cost (\$)
Silos 1 and 2 Radon Treatment System	2,066,735
Silos 1 and 2 Superstructures	5,820,000
Silos 1 and 2 Waste Retrieval System	2,177,400
Silo 3 Waste Retrieval System	2,286,300
Total	\$12,350,435

Some detail worksheets were provided for the waste retrieval cost. However, comparisons for this category were performed at a summary level. Several observations regarding the summary sheets are worth noting. Because detail comparisons were not performed, no firm conclusions are drawn.

- 1) Total personhours for site work and civil to prepare for the superstructures at Silos 1 and 2 equals 16,831. This is the equivalent of a nine member crew working full time for approximately one year. Having toured the site and seen the pilot superstructure constructed over Silo 4, such duration appears excessive.
- 2) Fabrication and transportation work includes \$433,300 for sandblast, prime and two finish coats of paint. Detail shows 665 tons at \$652 per ton. At \$3.15 per square foot (1.55 sandblast, 1.60 prime/double coat based on "Means Construction Cost Data"), the total (\$433,300) accounts for 137,555 square foot of surface area. A rough order of magnitude estimate indicates the total surface area of the combined structures to be approximately 30,000 square foot. At \$3.15 per square foot, this equals \$94,500.
- 3) In addition to the sandblast and painting, fabrication and transportation work includes \$579,600 for yard fabrication and fit verification, \$117,600 for transport to the site and

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\$100,000 to raise powerlines, traffic signals and trim trees. These totals also appear excessive; however, more detail is needed to draw definite conclusions.

- 4) Total personhours for assembly and erection on-site for the superstructures at Silos 1 and 2 equals 17,399. Again, this is the equivalent of a nine-member crew working full time for approximately a one year duration. Having toured the site and seen the pilot superstructure constructed over Silo 4, such duration appears excessive.
- 5) For Silo 3 waste retrieval equipment, engineering/design/inspection plus PM plus CM currently equals \$849,100. This amount equates to over 70% of the total direct plus indirect costs. Again, this percentage appears excessive when compared to industry standards.

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Appendix K

Comparison of Current Estimate with Feasibility Study Estimate

Table K1
Comparison Summary of Current Estimate to Feasibility Study Estimate

	Feasibility Study (in millions of dollars)	Alternative 2 (in millions of dollars)	Difference (in millions of dollars)
Site Preparation	1.9	1.6	(0.3)
Waste Processing	4.1	109.7	105.6
Vitrification Equipment	6.2	52.7	46.5
Hydraulic/Pneumatic Removal System	27.6	16.0	(11.6)
Demolition and Removal	13.3	80.0	66.7
Transportation	8.8	15.1	6.3
Disposal	3.1	24.9	21.8
Packaging	4.7	24.0	19.3
Disposal Vault	N/A ¹	N/A ¹	N/A ¹
O&M During Remediation	16.6	237.0	220.4
O&M Post Remediation	N/A ¹	N/A ¹	N/A ¹
Project Management	N/A ¹	48.0	N/A ¹

¹ N/A = not applicable, see discussion in text in Section K.

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K.1 Site Preparation

FS Assumptions – Site Preparation includes the cost for clearing and grubbing, fencing, filling, equipment staging area, roads, seed and mulch, trailers, security lights, transformers, water lines, sewer piping and an electric steam boiler.

Alternative 2 Assumptions – The site preparation costs for Alternative 2 are included with the waste retrieval cost.

The FS estimates the cost for site preparation of \$1.9 million. Alternative 2 site preparation costs are about \$1.6 million.

K.2 Waste Processing

One major difference between the FS and Alternative 2 is that the FS does not include a cost for pilot testing. That is, the cost is \$0. Alternative 2 assumes two phases to the VitPP. The first phase is estimated at \$12 million and the second phase at \$65 million for a total of \$77 million.

The section discusses these costs without the cost of the pilot plant included.

FS Assumptions – Waste Processing includes the costs for a two-story building, slab, two-foot thick concrete walls, ventilation system, general process area ventilation, separate ventilation system for radon if detected, RTS for process air, temporary staging and storage facility

Alternative 2 Assumptions – The cost for waste processing is included under the final remediation construction and final remediation engineering costs.

The total cost for waste processing under the FS is \$4.1 million. The cost for waste processing under Alternative 2 is \$109.7 million. The difference is notable. In fact, the engineering cost alone under Alternative 2 is more than 10 times the waste processing estimate under the FS.

K.3 Vitrification Equipment

As mentioned above, one major difference between the FS and Alternative 2 is that the FS does not include a cost for pilot testing (\$0 cost). Alternative 2 assumes two phases to the VitPP. The first phase is estimated at \$12 million and the second phase at \$65 million for a total of \$77 million. To put this in perspective, the Alternative 2 vitrification pilot cost is about 84% of the total cost of the FS estimate.

The section discusses these costs without the cost of the pilot plant included.

FS Assumptions – Vitrification Equipment includes costs for vitrification equipment (horizontal belt filter, filtrate recycle tank, surge tank, sodium carbonate and carbon storage/feed facilities, process piping, pumps, mixers and a joule-heated melter), RTS (for 1 and 2 and decant sump head space)(consists of blower, carbon adsorbers and dryers), off-gas system (blowers, scrubbers, carbon adsorbers and HEPA filters). The vitrification equipment would be designed to be operated for 24 hours a day at a rate of 13 tons per day. The RTS would be rated for 1,500 scfm.

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Alternative 2 Assumptions – Alternative 2 includes the costs for three parallel trains of six tons per day vitrification equipment. This is a combined total of 18 tons per day. The cost also includes the associated equipment. The RTS was rated at 300 scfm.

The cost for the vitrification equipment from the FS is \$6.2 million. The cost for the vitrification equipment under Alternative 2 is \$52.7 million. Although the equipment's design rate increases from 13 to 18 tons per day, this does not appear to explain an 8.5 times increase in the cost.

K.4 Hydraulic/Pneumatic Removal System

FS Assumptions – Hydraulic removal system includes rail-mounted truss, Plexiglas enclosure for the drive unit of the hydraulic removal equipment, RTS including building, slurry pump, below-grade concrete pit w/removable concrete lid between silo and processing facility which encloses the double-walled transfer piping. The truss would span 180 feet. Pneumatic removal system includes superstructure, work platform, rail system, filter/receiver, glove box (at dome/removal system interface) and pneumatic removal equipment (cutter head, vacuum and dredging pump).

The superstructure, rail system and work platform are similar components and not separate items between these two removal systems.

Alternative 2 Assumptions – Under Alternative 2 the superstructure is no longer assumed to ride on a rail system. In fact, two separate structures are assumed to be used to access Silos 1 and 2. Silo 3 is assumed to be accessed through the bottom of the tank. In the FS it was assumed to be accessed through the top using the same rail-mounted superstructure as Silos 1 and 2. This means that equipment for accessing the bottom of Silo 3 and an extra superstructure and work platform are required. Also, the rails and associated equipment will not be required. Furthermore, an extra superstructure was purchased for the use of a demonstration project under Alternative 2.

Cost – The cost for the removal system in the FS was \$27.6 million and for Alternative 2 is \$16 million. The cost for the Alternative 2 removal system is considerably lower than the FS cost, considering that the Alternative 2 removal system requires one extra full-sized superstructure and one smaller demonstration project superstructure.

K.5 Demolition and Removal

FS Assumptions – Demolition and Removal includes site preparation for above-grade disposal vault, haul road. Material would include: contaminated silo rubble, the existing RTS (1&2), surface and sub-surface soils, drum handling pad, decant sump tank, process piping and trenches, waste processing facilities and superstructure.

Alternative 2 Assumptions – This includes the costs for removing the superstructures, silos, pilot plant, old and new radon treatment systems, trailers, utilities and vitrification plant. It also includes some costs for soil removal. Additional costs are included for soil assumed shipped to NTS for disposal without treatment. This is \$40 million of the \$80 million in the waste packaging/shipping/disposal cost category.

The costs for demolition and removal from the FS are \$13.3 million.

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For Alternative 2 these costs are \$40 million under D&D/Soils Remediation and \$40 million under Waste Packaging/Shipping/Disposal, as mentioned earlier. This is a total of \$80 million. Part of this large increase in cost results from soil being packaged, transported and disposed off-site in the Alternative 2 estimate. Alternative 2 also includes D&D for two additional superstructures, a pilot plant and a vitrification plant that is much larger than the FS level vitrification plant.

K.6 Transportation

FS Assumptions – Packages would be transported via rail to within 300 miles of NTS and then transported by truck the rest of the way. The FS assumes that the waste in all three silos is vitrified, which reduces the original volume of waste prior to shipment for disposal.

Alternative 2 Assumptions – Under this alternative the waste is also assumed to be transported to NTS. However, the Silo 3 waste is assumed to be solidified (through solidification) rather than vitrified. This results in volume growth of the treated waste from Silo 3, which requires additional containers and trips. In the Alternative 2 estimate the waste is transported by truck alone.

Transportation costs for Silos 1 and 2 waste from the FS are estimated to be \$7.9 million and Silo 3 is estimated to be \$0.86 million. Under Alternative 2 these costs become \$13.2 million and \$1.9 million, respectively. Alternative 2 requires 1.3 times more containers for Silos 1 and 2 and 1.7 times as many containers for Silo 3.

K.7 Disposal

FS Assumptions – Disposal includes disposal at NTS. Disposal costs at NTS are \$10/cf.

Alternative 2 Assumptions – Under this alternative the waste also is assumed to be transported to NTS. However, the Silo 3 waste is assumed to be solidified (through solidification) instead of vitrified. This means that the volume of the treated waste from Silo 3 is going to be much larger. This will require additional containers. A 20% fee has been added to the cost for disposal. This additional fee appears to be because NTS charges for construction of new cells.

Cost – The cost for disposal for the FS was estimated to be about \$2 million for silos 1 and 2 waste and \$1.1 million for Silo 3 waste. Again, the Silo 3 waste was assumed to be vitrified in the FS. The cost for disposal for Alternative 2 is \$19.5 million for Silos 1 and 2 waste and \$5.4 million for Silo 3 waste. These costs exclude disposal of soils. Only waste from inside of the silos that has been treated are included. This is a large difference between the totals of \$3.1 million and \$24.9 million for the FS and Alternative 2 estimates, respectively.

K.8 Packaging

FS Assumptions – Packaging includes the cost of purchasing the container (DOT specification 7A-Type A) and labor associated with handling, filling and documentation.

Alternative 2 Assumptions – This includes the cost of the container and labor associated with handling and documentation (that is, certification). However, Scientific Ecology Group (SEG) concrete containers are procured for Silos 1 and 2 waste. The cost for each of these is nearly six

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times that of the standard metal boxes. Additional standard metal boxes are required for Silo 3 waste due to the cement solidification process replacing vitrification.

Costs – The cost for packaging for the FS is \$3.1 million for Silos 1 and 2 and \$1.6 million for Silo 3 waste. This is a total of \$4.7 million. The cost for packaging under Alternative 2 is \$20.6 million for Silos 1 and 2 and \$3.4 million for Silo 3. This is a total of \$24 million for Alternative 2. This difference in cost is found in the increased cost of the containers that are assumed required for Silos 1 and 2 and the increased number of containers required for Silo 3.

K.9 Disposal Vault

FS Assumptions – Vault design does not include radon or intruder barriers. Based on a unit cost. Based on a conceptual design of individual nodular cells, each capable of holding 120,000 cf of material. Assumes each package occupies 64 cf. The design of the vault includes a multimedia cap, liner and leachate collection/detection system.

Alternative 2 Assumptions – The cost for construction of the cells was not included under OU4. These costs were included under the estimate for OU5.

K.10 O&M – During Remediation

FS Assumptions – O&M During Remediation covers costs for material removal, treatment and disposal activities. Components include: O&M labor; materials and energy (treatment chemicals, additives, process water, electricity); and purchased services (sampling and analytical costs).

O&M costs under the FS are assumed to be \$16.6 million for all three silos. This can be broken down as \$11.7 million for Silos 1 and 2 and \$4.9 million for Silo 3. The FS did not include "hotel" costs because it was not assumed that the remediation of OU4 would last past the majority of the site being closed. The cost for O&M and landlord costs are, therefore, \$16.6 million.

Alternative 2 Assumptions – Operation of the vitrification plant and the solidification facility were estimated to cost \$60 million and \$1.2 million under Alternative 2. Alternative 2 also assumes that OU4 remediation work will not be completed before most of the rest of the facility is closed. Therefore, the "hotel" costs are estimated to be \$116 million plus an escalation of \$60 million. This is a total of \$176 million for site allocation costs alone. The total for O&M of the facilities plus the landlord costs are, therefore, \$237 million.

K.11 O&M – Post-Remediation

FS Assumptions – Post Remediation O&M covers the costs for long-term, on-site disposal. This includes maintenance and repair of the disposal facility or multimedia cap, media sampling and analysis (that is, air, surface water, groundwater and leachate) and maintenance and repair of ground-water monitoring wells. Duration was assumed to be 30 years. Costs for the on-property disposal facilities were scaled from the site-wide engineering waste management facility costs.

Alternative 2 Assumptions – Alternative 2 does not include O&M costs for post-remediation. These costs were to be included under the estimate for OU5.

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K.12 Project Management

FS Assumptions – The FS did not include separate costs for PM.

Alternative 2 Assumptions – Alternative 2 included \$48 million for PM. These costs could be spread out over each of the costs previously mentioned. However, many of these costs were much higher than one would anticipate anyway.

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Appendix L

Exhibits

Contacts

The following is a list of individuals contacted by the VE team during the study to seek professional information regarding proposals under consideration.

Name	Company	Telephone Number
William K. Weddendorf	FERMCO	(513) 648-4768
Mike Jannelli, CTL	FERMCO	(513) 648-3705
Don Paine	FERMCO	(513) 648-5310
Rex Norton	FERMCO	(513) 648-4322
Bob Heck	FERMCO	(513) 648-3051
Kim Gross	FERMCO	(513) 648-4118
Bob Rusch	FDF Consultant	
Doug Daniels	FERMCO	(513) 648-4344
Rod Gimpel	FERMCO	(513) 648-4842

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Meeting Record 3/11/97 8:30 -11:00 a.m.

Ed Barth EPA (513) 569-7669
(513) 569-7676 fax

John Kolts INEEL (208) 526-9909
(208) 526-0598 fax

Laura Tate CEMRO-HX-G (402) 697-2582
(402) 697-2595 fax

The meeting was to discuss the performance of various S/S processes in treatment of metals contaminated materials.

Each of the participants was convinced that most of the S/S processes can treat the materials that are free of significant organic contamination to pass TCLP. None of the participants was confident of the process limits on waste to solidification agent ratios with relatively high lead contamination.

The phosphate variations of the basic S/S processes was discussed briefly, but none of the participants had direct or specific experience with the variations. John Kolts and Ed Barth were interested in sponsoring further development of these process variations.

John Kolts outlined a suggested plan to gather more data with the Silo 1 and Silo 2 materials.

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Telephone Conversation Record 3/20/97 4:15 PM EST

Subject: A1.2 Air Pollution Control System

John Smets Flour Daniel, Irvine CA (714) 975-5120

Bob Bromm Flour Daniel, Irvine CA (714) 975-5120

Dave Yockman

Mark Wichman

Laura Tate

1. Vitrification drives off almost all existing radon and daughter products during the melt. There is a period of lower activity (by a factor of 1.4×10^4) after the glass is formed.
2. The emissions remain essentially constant before, during and after S/S processing.
3. Concern with porosity of S/S products allowing higher post-processing emission rate than the non-porous vitrification product.
4. Concern with high container leakage with stored S/S product.
5. Air flow rate is building 6 air changes/hour or greater.

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Appendix M

List of Documents Reviewed

- 1) Appendix D: Summary of Cement Stab., Chem. Ext., and Vit. Treatment Study, January 1994
- 2) Blue Ribbon Committee Report No. 2, November 1995
- 3) Chemical Fixation and Solidification of Hazardous Wastes
- 4) Chemistry of Hazardous Waste Stabilization
- 5) Choosing Solidification of Vitrification for LLRW and LLMW Treatment, February 1992
- 6) Draft Proposed Plan for Operable Unit 5, November 1994
- 7) Draft Radon Removal Process Evaluation and Sel. Study Report, November 1995
- 8) Executive Summary of Unnamed Report, October 1995
- 9) Feasibility Study Report for Operable Unit 4 (Vol. 1 of 4), February 1994
- 10) Feasibility Study Report for Operable Unit 4 (Vol. 2 of 4), February 1994
- 11) Feasibility Study Report for Operable Unit 4 (Vol. 3 of 4), February 1994
- 12) Feasibility Study Report for Operable Unit 4 (Vol. 4 of 4), February 1994
- 13) FEMP 04RI-6 Draft, November 1993
- 14) FEMP 04RI-6 Final, November 1993
- 15) FERMCO Change Proposal and Cost Savings Request Form, June 1996
- 16) Fernald Citizens Task Force - 1995 Tool Box, January 1995
- 17) Final Record of Decision for Remedial Actions at Operable Unit 4, December 1994
- 18) Field Off., October 1992
- 19) Life Cycle Benefit - Cost Analysis of Alts. For Deployment of the TVS, July 1996
- 20) Life Cycle Cost Estimates for the Vit. Of LLRW at FEMP, July 1994
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Appendix N

Acronyms

AEA	Atomic Energy Act
CA	Critical Analysis
CCC	Certified Cost Consultant
CM	Construction Management
CVS	Certified Value Specialist
D&D	Decontamination and Decommissioning
DOE	U.S. Department of Energy
DWPF	Defense Waste Processing Facility
EIT	Engineer in Training
EM	(DOE) Office of Environmental Management
EPA	U.S. Environmental Protection Agency
FDF	Flour Daniel Fernald
FEMP	Fernald Environmental Management Project
FERMCO	Fernald Environmental Restoration Management Corporation
FS	Feasibility Study
FTE	Full-Time Equivalent
FY	Fiscal Year
INEEL	Idaho National Engineering and Environmental Laboratory
IRT	Independent Review Team
K65	Pitchblende Ore Process
LCC	Life-Cycle Cost
LLRW	Low-Level Radioactive Waste
MAWS	Minimum Additive Waste Stabilization
MT	Metric Tonne
NRC	U.S. Nuclear Regulatory Commission
NTS	Nevada Test Site
NRTS	New Radon Treatment System
O&M	Operation and Management
OU	Operable Unit
PE	Professional Engineer
PM	Project Management

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PNL	Pacific Northwest Laboratory
R&D	Research & Development
RFP	Request for Proposal
ROD	Record of Decision
RTS	Radon Treatment System
SEG	Scientific Ecology Group
S/S	Solidification/Stabilization
TCLP	Toxicity Characteristic Leaching Procedure
USACE	U.S. Army Corps of Engineers
VE	Value Engineering
VIT	Vitrification
VitPP	Vitrification Pilot Plant
VSL	Vitrous State Laboratory
WMB	White Metal Boxes
WVDP	West Valley Demonstration Project

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